FARM MACHINERY

BY

ARCHIE A. STONE

Head, Department of Farm Mechanics, N. Y. State Institute of Applied Agriculture, Farmingdale, N. Y.

Member, American Society of Agricultural Engineers

NEW YORK

JOHN WILEY & SONS, INC.

LONDON: CHAPMAN & HALL, LIMITED

1922

To My Father

WHO FOR MORE THAN HALF A CENTURY HAS HAD AN ACTIVE INTEREST
IN FARM MACHINERY AND HAS AIDED IN ITS DEVELOPMENT
FROM THE CRADLE TO THE COMBINE

THIS BOOK IS AFFECTIONATELY DEDICATED

PREFACE

THE present volume is intended primarily for use in schools and departments of vocational agriculture. In addition, however, it should be of value in college courses in farm machinery as well as of practical assistance to farmers and mechanics who desire to improve their ability to repair farm machinery.

Since the passage of the Federal Vocational Education Act and the establishment of courses in vocational agriculture, in special schools and departments there has developed an increasing demand on the part of directors and teachers for assistance in selecting content of instruction in farm machinery. It appears that this demand has come about because of the increased recognition of the need on the part of vocational pupils for abilities that would enable them to select, maintain and repair the machinery needed for conducting the particular type or types of farming for which they were preparing. The acquiring of such skills as are involved in the correct assembly of parts, adjusting and readjusting parts, replacing parts, lubricating, providing the most effective utilization of power, handling and controlling in action, repairing and housing, requires systematic instruction. "Pick up" methods are costly in time, money and effort. The shop and the supervised farm practice are of basic importance to the effective teaching of machinery skills. The content in farm machinery must grow out of farm machines themselves and not out of books about machines.

In the preparation of this volume careful thought has been given to the needs of pupils preparing for specific farming occupations. The problem attitude has been

maintained throughout. The "shop jobs" and "laboratory studies" are organized so as to stimulate interest in the actual study of machinery problems and to give specific directions for conducting the work in an orderly manner. By these devices and by the inclusion in each chapter of content regarding machinery types, parts and adjustments it is hoped that vocational pupils will be assisted in acquiring the abilities necessary to maintain and repair machinery on the home farm or on the farm where they are employed.

The author wishes to express his appreciation of the interest and enthusiastic aid of Dr. O. S. Morgan, Professor of Agriculture, Columbia University, New York City. Credit is also due to Robert H. Smith, Instructor in Farm Engineering and Mechanics at the New York State School of Agriculture at Canton, N. Y., for assistance in the preparation of the work on the Fordson ignition system; to the author's wife, Rowena Stone, for all of the pen and ink sketches; to the New York State Institute of Applied Agriculture at Farmingdale, N. Y., for many facilities and much valuable material; to Miss Lottie Scally, Martin B. Dugan, and the following instructors at the New York State Institute of Applied Agriculture, for their kindly interest, Leon D. Stephens, Fordyce C. Dietz, K. H. Musa, C. A. Peters, G. L. Franke, D. Z. Terhune, D. R. MacDougal and L. L. Kenfield.

THE EDITORS AND AUTHOR.

CONTENTS

PART I

PART II

FOREWORD

We are living in an age of machinery, on the farm and in the city. Farm machinery has come to be a vital factor in successful agricultural production. The high cost and scarcity of farm labor has made the use of machinery imperative. It is the machinery on the farm which makes it possible for such a small number of farmers to produce sufficient food for our increasing population. The efficient utilization of machinery is the chief reason why American farmers are increasing the production per man so far ahead of their forefathers and so far in advance of the production per man in most European countries. The cost of maintaining farm machinery including depreciation, repairs, interest and housing is one of the largest annual expenses of the average farm.

The benefits of modern machinery to agriculture are many. It cuts production costs, results in a better quality of work and brings relief from drudgery. A man's time employed in work that might be done by a machine is ill spent. He can, at best, develop little more than one-eighth of a horse power. When employed in controlling the work of a machine his power is multiplied.

No matter how well made a machine may be, if it is not intelligently used, imperfect and costly work may result. Most farm machines have many fine adjustments, which if properly made, improve the quality of the work and adapt the machine to varying conditions.

It is too often true that farm machines receive attention only when immediately needed in the field and then only such attention as will render them capable of inferior work.

On the other hand there are many farmers who take great pride in the fine appearance of their fields, their uniform, well-pulverized plowing, their straight rows, the accuracy of their plowing, their well-shaped bundles of grain, etc. These desirable results are not attained because of experienced driving only, but because of an understanding of the construction and basic adjustments of the machines performing the work. Such a farmer may find that his binder will last for twenty years while another must replace his in five or six years. Many of the modern farm machines are intricate in construction and require an alert, well-trained operator.

As man labor on the farm decreases the farmer becomes more dependent upon his machines. Most field work is seasonable and delays are costly. Mechanical trouble, when work is pressing, is serious. Thorough overhauling and conditioning of farm machines, well in advance of their use in the field, is essential.

The large investment in farm implements, the high quality of work accomplished by farm machines when efficiently operated and the extra years of service that intelligent care always gives, justify a systematic and practical study of farm machinery, in the laboratory, repair shop and in the field.

This is the viewpoint from which this text has been developed. A few typical machines have been selected from the large number available. These few have been treated with considerable mechanical detail and the text, therefore, does not offer general information on a large number of farm machines. The methods described for studying, repairing and operating can easily be applied to implements not treated in the text.

A. A. Stone.

FARM MACHINERY

CHAPTER I

PLOWS

The plow is one of the most important of all farm machines. It is an indispensable tillage implement. Plowing is an essential process in the preparation of the seed bed. More thought and engineering talent have been employed in the design and development of the plow than in that of any other implement. Although the plow seems a simple tool, good plowing is an art, requiring knowledge, skill, and experience.

The chief use of the plow is in preparing the seed bed. It inverts the upper layer of soil and turns under and completely covers all surface growth, thus adding humus to the soil. Plowing pulverizes, aerates and loosens the soil, making it more friable and mellow.

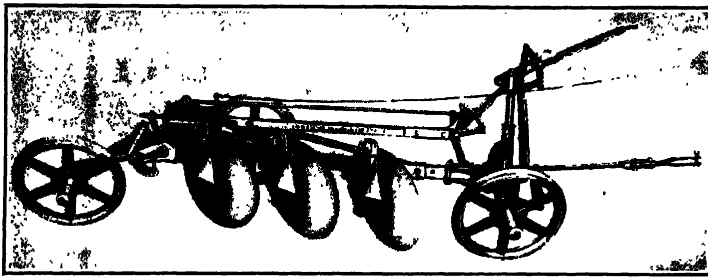
The plow is also used to turn under and thus destroy weeds. It is sometimes used to open the furrow for planting certain crops and to cover the seed of such crops.

Types and Sizes of Plows.—There are two distinct types of plows in common use:

1. Moldboard plows;
2. Disk plows.

The first type is more widely used and in general gives better satisfaction than the latter. In some soils, however, moldboard plows will not "scour." The soil will stick to the moldboard and thus make good plowing impossible. Under such conditions the disk plow is used to good advantage. The

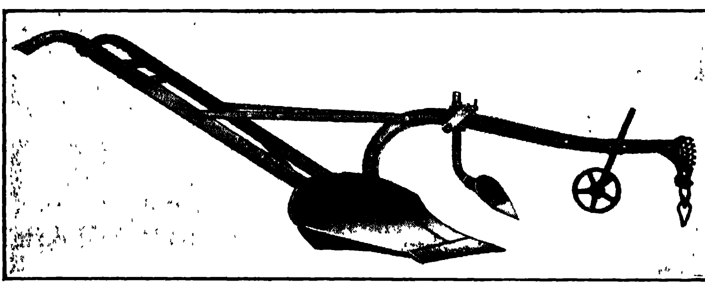
revolving disks are equipped with scrapers which keep them free from sticky soil. Figure 1 shows one type of disk plow.



Courtesy of Oliver Chilled Plow Co.

FIG. 1.—Tractor disk plow.

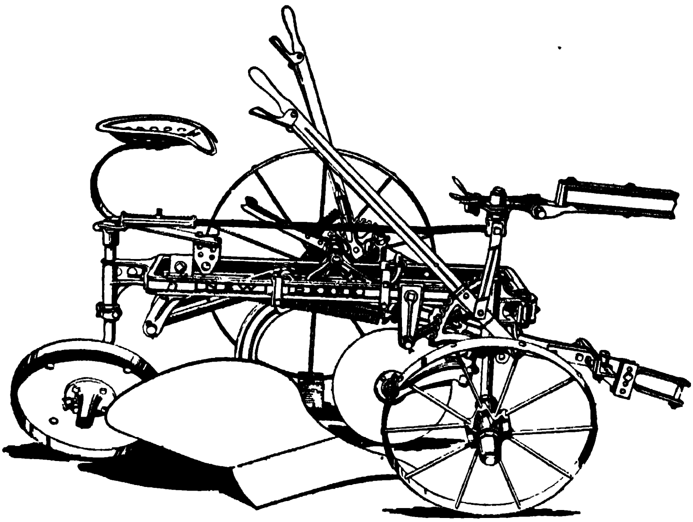
Under average conditions, however, moldboard plows pulverize the soil better, leave fewer clods, and cover surface growth more completely than do disk plows.



Courtesy of Oliver Chilled Plow Co.

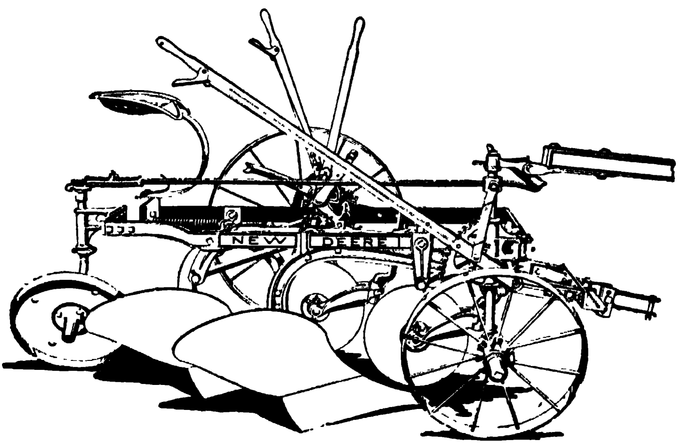
FIG. 2.—Walking plow.

The walking plow (Fig. 2) is found on most farms, even on farms where larger plows are used. It is used for small fields, where a larger plow cannot be employed to advantage. The size of the walking plow is measured by the width of the furrow that it cuts. The most common sizes are 12, 14, and 16 in.



Courtesy of Deere & Co.

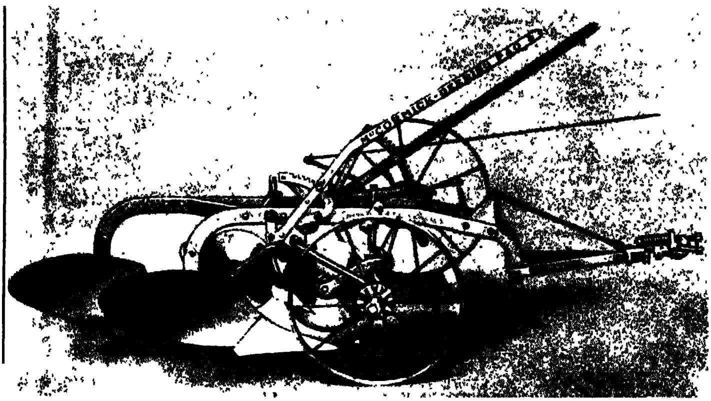
FIG. 3.—Sulky plow.



Courtesy of Deere & Co.

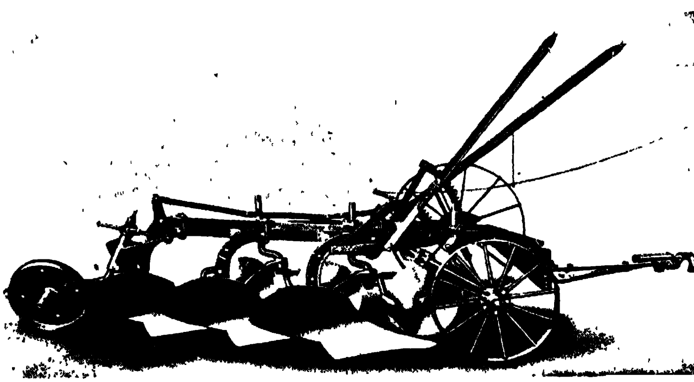
FIG. 4.—Gang plow.

Riding plows carry the weight of the plow on the wheels, and make it possible for the operator to ride. The single-



Courtesy of International Harvester Co.

FIG. 5.—Two-wheel tractor plow.



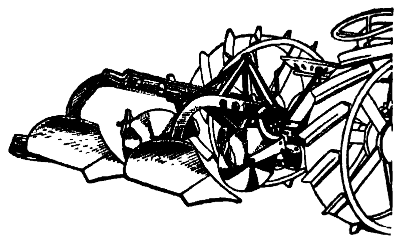
Courtesy of International Harvester Co.

FIG. 6.—Three-wheel tractor plow.

moldboard riding plow (Fig. 3) is called a "sulky" plow. Sulky plows are usually equipped to cut a 14- or 16-in. furrow.

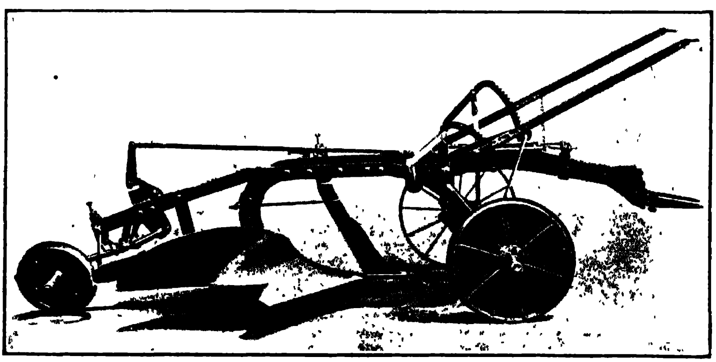
Riding plows with two or more moldboards are referred to as "gang" plows (Fig. 4). Gang plows are commonly furnished with 12- or 14-in. bottoms.

Tractor plows (Figs. 5 and 6) are usually mounted on wheels. Both two-wheel and three-wheel tractor plows are commonly used. Figure 7 shows a recent type of tractor plow which is carried directly on the rear of the tractor, thus eliminating all wheels. The number of plow bottoms used varies from a single one to as many as twelve. The width of the bottoms on tractor plows also varies. Probably 14-in. bottoms are the most common. Twelve and 16-in. bottoms are also often used.



Courtesy of Ferguson Sherman Inc.

FIG. 7.—Wheelless tractor plow.



Courtesy of International Harvester Co.

FIG. 8.—Brush breaker.

Tractor plows, designed especially for plowing brush land and newly cleared ground, may have a bottom as wide as 20 or 24 in. (Fig. 8).

Plow Bottoms.—The plow bottom is the part of the plow that enters the ground and cuts and turns the furrow. As plows are used under many different conditions and on many kinds of soil, various shapes of plow bottoms have been developed, each being suited to a definite set of conditions. There are a great many different shapes and styles of plow bottoms, but all may be divided into three general classes.

Types of Plow Bottoms.

1. Breaker Bottom or Prairie Breaker (Fig. 9, *A*).—The prairie breaker bottom is low. It has a long, easy slant and turns the furrow over gradually, thus pulverizing the soil very little. This type is used for plowing virgin soil or fields that have a heavy sod. An extension is often bolted to the rear of the moldboard to aid in turning over the furrow slice. (Fig. 9, *A*, *b*.)

2. General-purpose Bottom (Fig. 9, *B*).—The general-purpose

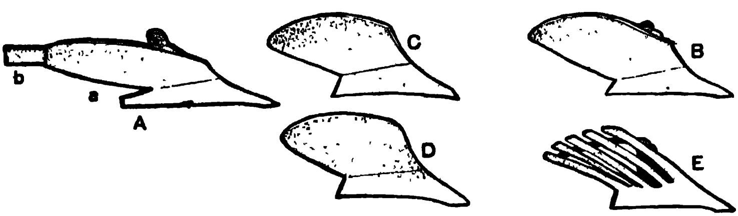


FIG. 9.—Types of plow bottoms.

bottom is higher and turns the furrow more abruptly. Hence it pulverizes the soil more than the breaker bottom. It is used on fields of light sod or on ground that has been in crop the previous year. It is not suited for work on virgin soil.

3. Stubble or Old-land Bottom (Fig. 9, *C*).—The stubble or old-land bottom turns the furrow quite abruptly and pulverizes more completely than either the general-purpose or the breaker bottom. It is used on old ground that has been in crops for many years. It leaves the soil mellow and finely pulverized.

The stubble bottom cannot be used successfully on new ground or on grass land.

These are the three types of plow bottoms in general use. There are a great many variations within these classes.

4. Special Plow Bottoms.—The black-land bottom has an abrupt angle. The pressure of the soil against it is very heavy. It is used for plowing in black, sticky soils. The shape and angle of the moldboard is such that the soil does not stick to it, but slips off, or "scours," easily (Fig. 9, *D*).

The slat moldboard has about the same shape as the black-land bottom. There is less metal surface in the moldboard for the soil to stick to, hence this type is used where ordinary moldboards will not "scour" (Fig. 9, *E*).

Plow-bottom Materials.—The various conditions under which plows are used have caused the manufacturers to employ different materials in the construction of plow bottoms. Each material has certain advantages, and the proper one may be obtained for any plowing condition.

1. Chilled Cast Iron.—Plow bottoms made of chilled cast iron are used in sandy or sandy-loam soils. They are not adapted for clay soils or heavy, sticky soils. Such soils will stick to them and make it impossible to do a good job of plowing. A cross section of a piece of chilled cast iron is shown in Fig. 10, *A*. When the molten iron is poured, one face of the mold is lined with metal. As the molten iron strikes this metal it cools very quickly. This causes the crystals of metal to turn on edge. These crystals are very hard and resist well the wearing effect of the soil.

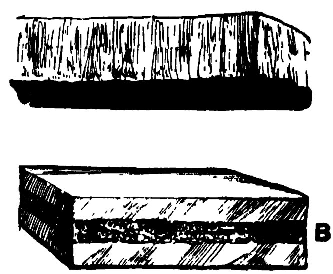


FIG. 10.—Plow-bottom materials.

The parts of the chilled cast-iron bottom are comparatively cheap. When the shares have worn out of shape, however, they cannot be reshaped but must be thrown away, as cast iron

cannot be forged. Because of their cheapness, this is not a serious objection to their use, and they are widely used where the soil conditions are suitable.

2. Soft-center Steel.—A cross section of a piece of soft-center steel is shown in Fig. 10, *B*. This is made of three layers welded together. The two outside layers are of hard steel. The inner layer is of softer steel, which acts as a cushion for the outer layers. The hard steel comes into contact with the soil. It is very smooth and takes a high polish. Clay soils and heavy soils do not stick to it but are readily shed. Hence this material is used where the soil is heavy or where cast-iron plow bottoms will not scour. The soft inner layer helps to prevent breakage.

Soft-center steel plow bottoms are more expensive than those of chilled cast iron. Soft-center steel shares, however, may be reshaped by forging when they are worn. The process of sharpening steel shares will be discussed later.

These shares are likely to break in rocky land, but do not break as easily as chilled-iron shares. They wear faster in sandy soils than chilled iron, but for plowing on heavy or sticky soils they give much better results. Soft-center steel plow bottoms are lighter in weight than chilled-iron bottoms.

3. Crucible-steel Shares.—Crucible or solid-steel shares are sometimes used with a soft-center steel moldboard. This steel is softer than soft-center steel and is not satisfactory for use where scouring conditions are difficult.

Crucible-steel shares are cheaper than those of soft-center steel. They may be sharpened easily with a file, or hammered without heat. They are good for use on rocky ground as the steel is comparatively soft and does not break easily.

WALKING PLOWS

CONSTRUCTION AND PRINCIPAL PARTS

1. Frog (Fig. 14, *a*).—The frog is the heart of the plow bottom, all the other parts being attached to it. The frog may be made of cast iron or steel. The cast-iron frog is larger and thicker than the steel frog. An easy method of distinguishing between cast-iron and steel parts is to observe the manner in which they are numbered. If the number has been stamped into the metal, the part so numbered is steel. If the number is raised, showing that the figures or letters were molded with the part, the material is cast iron.

2. Share (Fig. 11).—The share cuts the furrow loose and elevates it to the moldboard. Shares are made of chilled iron, soft-center steel, or crucible steel. They are carefully shaped, as the correct shape is essential to good plowing. An old share fails to do good work not only because it is dull but because it has lost its original shape. In Fig. 11, *c* shows the point, and *d* the wing, of a walking-plow share. The share is bolted to the frog, or attached to it by means of a steel lug and eye bolt. Shares attached in the latter manner or with a similar device are called "quick detachable shares." They are now more commonly used than bolted shares, particularly on riding and tractor plows. With "quick detachable shares" bolt holes through the shares are not necessary.

The question of sharpening chilled-iron and soft-center steel shares will be treated in Job No. 2.

3. Moldboard (Fig. 11, *b*).—The moldboard lifts and turns the furrow cut loose by the share. The angle that the moldboard makes with the landside determines the amount of pulverization that will take place. This angle is small on the breaker plow, with the result that the furrow is turned gradually and the soil is pulverized very little. The angle between the moldboard and landside of a stubble-bottom plow is quite abrupt. Such a moldboard turns the furrow quickly and pul-

verizes it well. The angle of a general-purpose plow bottom is less than that of the stubble bottom but more than that of the breaker bottom. Note the angle indicated in Fig. 12 between *a*, *b* and *d*.

Special plow bolts are used to attach the moldboard and the other parts of the plow bottom to the frog. These are countersunk so that the head of the bolt will be flush with the surface. Round-head bolts, with a small tit to prevent turning, or square-head bolts are used.

Moldboards are made of chilled iron or soft-center steel.

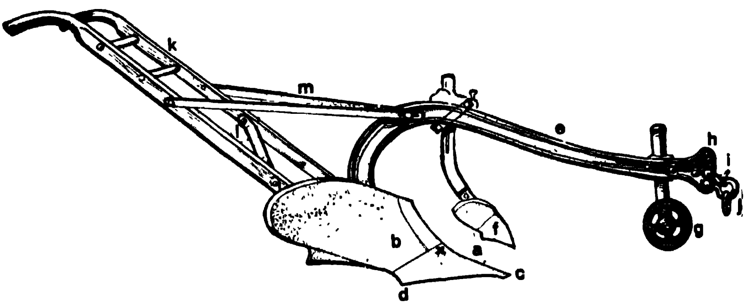


FIG. 11.—Parts of the walking plow.

The surface of the moldboard must be very smooth and capable of taking a high polish. Good plowing requires that the soil pass off easily from the moldboard without sticking. The shedding of the soil from the moldboard is called "scouring." The manufacture and design of plow moldboards that will scour well under adverse soil conditions are sources of continual experiment for the plow maker and the problem of skillful and intelligent management of the plow under such conditions should receive the best effort of the plow operator.

Figure 11 shows a moldboard with a removable cutting edge. This is called the "shin" of the moldboard. As most of the wear comes at this point there is an advantage in having a removable shin.

The extra joint, however, between the shin and the moldboard sometimes interferes with scouring when soil conditions are difficult.

4. Landside (Fig. 14, *d*).—The landside presses against the wall of the open furrow. It keeps the plow straight and resists the side pressure on the moldboard caused by the turning over of the furrow.

5. Beam (Fig. 11, *e*).—Plows are pulled from the beam, which is bolted to the frog. The beam is curved upward where it passes over the plow bottom to give throat room or clearance for trash at this point.

Either wood or high-carbon steel is used for walking-plow beams. The wood beam is larger than the steel beam, but lighter. The steel beam is now the more widely used.

6. Jointer (Fig. 11, *f*).—The jointer is commonly used with the walking plow. It is fastened to the plow beam with an adjustable clamp. The adjustment of the jointer is very important and will be thoroughly explained later in this discussion. The jointer is a miniature plow. It cuts and turns a small furrow at the inner edge of the main furrow. This causes better covering of surface growth when the main furrow is turned over. Jointers are particularly useful in plowing sod fields or in turning under growing crops to enrich the soil.

7. Gauge Wheel (Fig. 11, *g*).—The gauge wheel is connected to the beam, the clamp that holds it providing for vertical adjustment. The gauge wheel keeps the plowing uniform in depth and causes the plow to run steady.

8. Clevises (Fig. 11, *h* and *i*).—The clevis is a device for connecting the plow to the power that draws it. Walking-plow clevises are made to provide both vertical and horizontal adjustment. Figure 11, *h*, shows the vertical clevis. This is bolted to the end of the beam. The horizontal or cross clevis is shown at Fig. 11, *i*. The series of holes in the vertical clevis makes it possible to raise or lower the point of hitch. The holes in the horizontal or cross clevis make it possible to move the point of hitch toward or away from the "land" (unplowed ground).

The small clevis (*j*), which is called the evener clevis, connects the eveners with the cross clevis. The clevises are connected with each other by bolts or pins.

The subject of plow hitches and methods of adjusting the clevises is explained on page 54.

9. Eveners (Fig. 25).—Two-horse eveners are used for walking plows. Figure 25, *b*, shows the evener bar, *c* and *d* the single trees, *e* the single-tree hooks. The traces of the horses' harness are hooked to the single-tree hooks. The single trees are attached to the evener bar by means of metal straps (*f*). The various evener parts to which these letters refer are shown in Fig. 25, as part of a five-horse hitch. The parts mentioned here, however, are all used, as stated, with the walking plow.

10. Plow Handles (Fig. 11, *k*).—Plow handles are usually made of wood, a good grade of oak being used for this purpose. Heavy steel bars (Fig. 14, *c*) connect the lower ends of the handles with the plow bottom. Usually the left handle is bolted to the frog, and the right handle to the back of the moldboard. Figure 11, *l* and *m*, illustrates the method of bracing the handles.

The operator guides and controls the plow by means of the handles.

Set of the Walking-plow Bottom.

1. Vertical Suction (Fig. 12).—If a new walking-plow bottom is placed on a level floor, it will touch the floor in three places: the point of the share (*a*), the wing of the share (*b*), and the heel of the landside (*d*). There should be a clearance of $\frac{3}{16}$ to $\frac{1}{4}$ in. at the point indicated by the arrow (*c*). There should also be a clearance of $\frac{1}{8}$ to $\frac{3}{16}$ in. at the point indicated by the arrow (*e*). This clearance is caused by the fact that the point of the share is lower than the line of landside, and also lower than that part of the cutting edge of the share indicated by the arrow at *e*. When the share is made, the point, from the arrows forward, is bent downward. This causes the point of the share to enter the ground first. The plow penetrates easily and stays in the ground because of the downward inclination of

the point. The action of the point in entering the ground and holding the plow bottom down so as to cut the proper depth of furrow is referred to as "vertical suction." The point of a worn share is shown in Fig. 13. The underside of the point has been worn away. Such a share would give no "vertical suction," and the plow would not penetrate properly.

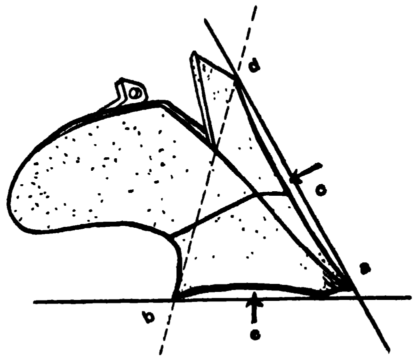


FIG. 12.—Set of the walking-plow bottom.

2. Horizontal Suction (Fig. 14).—If a new walking-plow bottom be turned on its side on a level floor it will be noted that the heel of the landside and the point of the share touch the floor. There will be a clearance of $\frac{1}{8}$ to $\frac{1}{4}$ in. at the point indicated by the arrow at *e*, because the point of the share is turned slightly to the side, or outside the line of the landside.

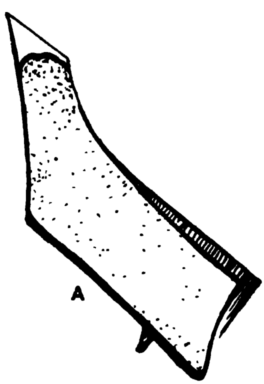


FIG. 13.—Worn plow shares.

When the plow is in operation the share point tends to suck its way sideward, or toward the "land," because the share point is bent toward the side. This is referred to as "horizontal suction," or "land suction." A plow bottom with good land suction cuts a uniform width of furrow. It maintains the same width of furrow in all parts of the field.

Figure 13, *A*, shows a share worn so much that the plow would have no land suction. Plowing with such a share would be very difficult; the plow would not hold the land, the furrows would not be even in width, and the operator would have to force the plow to cut more land by manipulating the plow handles. The pressure of the furrow being turned over by the moldboard has a tendency to pivot the plow bottom, turning the share point toward the plowing (away from the land). This tendency is partly overcome by the landside, but also to a large extent by the land suction of the share point. Consequently, a share point that is worn so that it does not give proper land suction should not be used.

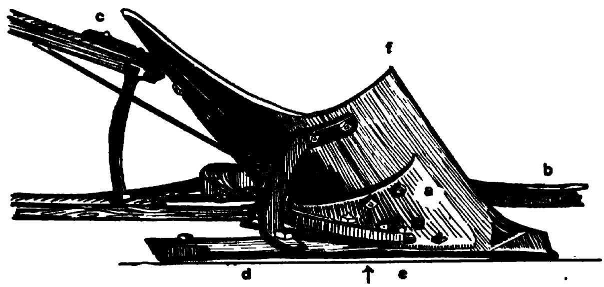


FIG. 14.—Inverted view of walking plow bottom.

3. Wing Bearing (Fig. 14,*f*).—The wing of the share is one of the three points to touch the level floor. The share at this point, however, is made level for about 1 in. in order to provide a bearing for the outer corner of the plow bottom. This portion of the bottom of the share (indicated at *f*) is called the "wing bearing." This bearing is usually about 1 in. along the under surface of the share for 14-in. plows.

The wing bearing serves as a runner to support the plow bottom and keep it running steadily.

LABORATORY STUDY NO. 1

To inspect and study the construction of a walking plow.

Equipment Necessary.—A walking plow, complete with all parts.

Procedure:

1. Set the plow on a level floor. Measure the clearance at the point indicated by the arrow at *c*, Fig. 12.
2. Measure the clearance at the point indicated by the arrow at *e*, Fig. 12.
3. Turn the plow over on the landside and measure the clearance indicated by the arrow at *e*, Fig. 14.
4. Answer the following questions:

    (*a*) What is meant by vertical suction?
    (*b*) What causes a plow bottom to lose its vertical suction?
    (*c*) What is meant by horizontal or land suction?
    (*d*) What causes a plow bottom to lose its horizontal or land suction?
    (*e*) How may the vertical or horizontal suction be restored to a plow bottom which has a steel share?

5. Measure the width of the plow bottom. (Width of furrow it will cut.)
6. Remove the share from the frog.

    (*a*) Is it a bolted or a quick-detachable share?
    (*b*) What advantages have the quick-detachable shares?
    (*c*) Is the share made of steel or of chilled iron?

7. Remove the landside from the frog.

    (*a*) Measure the length and height of the landside. What is the advantage of a long and high landside?
    (*b*) Is the heel of the landside reinforced? Is it detachable?

(*c*) How many bolts are used to attach the landside to the frog?
(*d*) What kind of bolts are used?
(*e*) Is the landside made of steel or of cast iron?

8. Remove the moldboard from the frog.

(*a*) In which of the three general classes of moldboard shapes would you place this one; breaker, general-purpose, or stubble?
(*b*) Under what conditions would you use this type of moldboard?
(*c*) Of what material is the moldboard made?
(*d*) How many bolts pass through the moldboard?

9. Remove the beam.

(*a*) How many bolts are used to hold the beam in place?
(*b*) What material is used in the construction of the beam?
(*c*) What is the purpose of the beam?
(*d*) What parts of the plow are attached to it?

10. Examine the frog.

(*a*) Of what material is it made?
(*b*) A cast-iron frog is larger than one made of steel. Why?
(*c*) What is the purpose of the frog?

11. Examine the plow handles.

(*a*) What material is used in their construction?
(*b*) How are they braced?
(*c*) How are they attached to the plow bottom?

12. Study the construction of the jointer.

(*a*) What is its purpose?
(*b*) How is it attached to the beam?

(c) Is the jointer adjustable? Can it be adjusted both vertically and horizontally?

13. Remove the gauge wheel from the beam.

(a) Is the gauge wheel adjustable vertically?
(b) Is it adjustable horizontally?
(c) What is its purpose?

14. Examine the plow clevises.

(a) Why is a vertical clevis with several adjusting holes necessary?
(b) Why is a horizontal or cross clevis with adjusting holes necessary?
(c) How is the vertical clevis connected to the plow beam?
(d) How is the cross clevis connected to the vertical clevis?
(e) What is the purpose of the evener clevis?

15. Examine the eveners.

(a) What is the purpose of the single-tree hooks?
(b) How are the single-trees connected to the evener bar?
(c) How is the evener bar connected to the plow?
(d) Where do the eveners wear?

16. Reassemble the plow. Make sure that all parts are properly fitted. The heads of the bolts should be flush with the surface of the plow-bottom parts. If these bolt heads project beyond the face of the share, moldboard, or landside, the soil will be caught by them, and this may result in poor plowing. The joints between the plow-bottom parts should be even and tight.

17. Measure the vertical distance between the point of the share and the beam. Measure vertically from *c* to *e*, Fig. 11. Compare this measurement on several plows if possible.

(*a*) What is the advantage of ample distance at this point?

18. Measure the width of the wing bearing of the share.

(*a*) Why is this bearing necessary?

19. Grease the surface of the share, moldboard, landside, and face of the jointer to prevent rusting.

Job No. 1

TO REPAIR A WALKING PLOW

Operations Necessary to Perform the Job.

1. Inspect the set of the plow bottom.
2. Sharpen or replace the share.
3. Inspect the landside and replace it if necessary.
4. Remove all rust spots from the moldboard and inspect it for wear.
5. Tighten all bolts in the plow bottom. Secure an even joint between the moldboard and the share.
6. Repair the plow beam as required.
7. Sharpen the jointer.
8. Adjust the bearing of the gauge wheel.
9. Replace worn clevis bolts.
10. Repair the eveners.
11. Tighten all bolts in the plow handles.
12. Paint all metal parts except the surface of the share, moldboard, landside, and jointer. Cover these with heavy grease. Paint all wooden parts.

Description of Operations.

1. Place the plow on a level floor and examine the set of the plow bottom to determine.

(*a*) The amount of vertical suction;
(*b*) The amount of land suction;
(*c*) The amount of wing bearing.

(See Laboratory Study No. 1.)

2. Sharpen and reshape the share or replace it with a new one if necessary (see Job No. 2, p. 23).

3. Examine the landside and the landside sole for wear. If these parts are badly worn they should be replaced. Landsides wear most at the under side toward the rear. They sometimes wear so much as to become considerably shorter than when new.

4. Examine the moldboard. Remove all rust spots with emery paper. Moldboards last longer than shares or landsides, but sometimes become worn or scratched so much that they must be replaced. The end of the moldboard is sometimes worn off by dragging the plow to and from the field, allowing it to ride on the end of the moldboard. To prevent this, a drag made of planks should be provided.

5. Examine all the bolts that hold the landside, share, and moldboard to the frog. Tighten these bolts and see that the bolt heads do not project from the surface of these parts. The joint between the share and moldboard must be smooth and even. If the moldboard were higher than the edge of the share the soil would stick to it and the plow would not scour properly. Shims of cardboard placed between the share and the frog will bring the share up into line properly, or if the moldboard is too low the shims may be placed between it and the frog.

6. Examine the beam (if a steel beam is used) to see if it is straight. To straighten a bent steel beam, proceed as follows:

(*a*) Determine the exact point where the beam is bent.

(*b*) Remove the beam from the plow and take off all parts attached to it.

(*c*) Heat the beam in the forge, at the place where it is bent, to a dull cherry red.

(*d*) Hammer the beam on the anvil so as to bring the bent portion back into place.

The chief difficulty in straightening a bent beam is in keeping it at the proper heat. Too much heat will change the temper of the steel and weaken the beam.

(*e*) If another plow beam of the same type is available, compare the two. Wooden beams will not bend, but may crack or break. In this case they should be replaced.

Examine all the bolt holes through the beam (wooden beam). Test to see if the bolts completely fill the holes in the beam. If they do not, the bolts will loosen when the plow is in operation, making it impossible to keep the parts properly adjusted.

There are two methods by which this condition may be remedied:

(*a*) By using a larger bolt: To do this it is usually necessary to enlarge the hole through the metal part also, so that the larger bolt will pass through it. This may be done by drilling or reaming out the hole. If the hole needs to be enlarged only slightly, the work may be done with a round file.

This method is the best to use where the metal part is of such a size that a larger hole will not be likely to weaken it.

(*b*) By shaping a hard-wood plug to fit the hole: Cover the plug with glue and drive it into the hole. When the glue is set, bore out the hole to its original size, and use the same size bolt. This method is best where the metal piece is likely to be seriously weakened if the hole through it is enlarged.

These two methods will be found useful in repairing many kinds of farm machines.

7. Sharpen the jointer. This may be done by grinding it on the grindstone or emery wheel on the under side of the cutting edge.

8. Inspect the bearing of the gauge wheel. This is usually made so that it can easily be replaced when worn.

9. Tighten the bolts that hold the vertical clevis to the beam. Examine the clevis bolts and replace them if they are worn.

10. Examine the eveners. Walking-plow eveners are usually made of wood. The single-tree hooks sometimes get loose, and the bolts or pins through the single-tree straps and evener straps should be made to fit properly the hole through the wood. (See Operation 6 of this job.)

11. Tighten the bolts that attach the handles to the plow bottom. Examine the handle braces. Replace broken or split handles.

12. Paint all the metal and wooden parts of the plow except

the wearing surfaces of the share, moldboard, and landside. These surfaces should be covered with a thick coating of heavy grease. This prevents the rusting of these highly polished parts, and the grease can be easily wiped off when the plow is to be used again. Rust is the great enemy of farm machinery. Plow bottoms, in particular, are quickly damaged by rust. A small rust spot on the share or moldboard of the plow may cause a great deal of trouble and make good plowing impossible.

All farm machines should be painted before they are stored away after the season's work. Paint costs little and greatly lengthens the life of machinery. A good repair job is not complete without painting.

Job No. 2

TO SHARPEN PLOW SHARES

Operations Necessary to Perform the Job.

1. Determine what material the share is made of (see p. 9).
2. Grind chilled cast-iron shares on the emery wheel or grindstone.

To sharpen soft-center steel shares:

1. Secure suitable fire in the forge.
2. Draw an outline of a new share on the floor with chalk.
3. Heat the share in the fire as directed in the "Description of Operations."
4. Hammer the heated portion of the share on the upper side.
5. Heat and forge the share point.
6. Bend the share point down to give vertical suction.
7. Temper the cutting edge of the entire share.

Description of Operations.

1. Determine whether the share is made of chilled cast iron or soft-center steel (see p. 9). Cast-iron shares cannot be forged. 2. If the share is made of chilled cast iron, grind the entire cutting edge on the emery wheel or grindstone. It should be ground to an abrupt beveled edge. A thin edge will not have the strength to resist the severe wear to which plow shares are subjected. Make the edge sharp but with an abrupt, steep angle. Grind on the upper side of the share.

Chilled-iron shares that are worn to the extent shown in Fig. 13 have lost their land and vertical suction. It is useless to sharpen such shares, as they cannot be restored to their original shape. Such shares should be replaced with new ones. Chilled-iron shares cannot be heated and forged.

Sharpening Soft-center Steel Shares (Fig. 15).

Note.—Sharpening steel shares is the most difficult of all plow-repair work. It is discussed here because a knowledge of the proper shape of the share and of the importance of sharp

shares is vital. Unless the student has ample opportunity for practice and has had some previous experience in working steel, this problem had better be delayed until the latter part of his course. The various steps given below should, however, be carefully studied; or, better still, the student should be afforded the opportunity of watching a skilled blacksmith reshape and sharpen a soft-center steel share.

1. Obtain a good, clean coke fire in the forge.

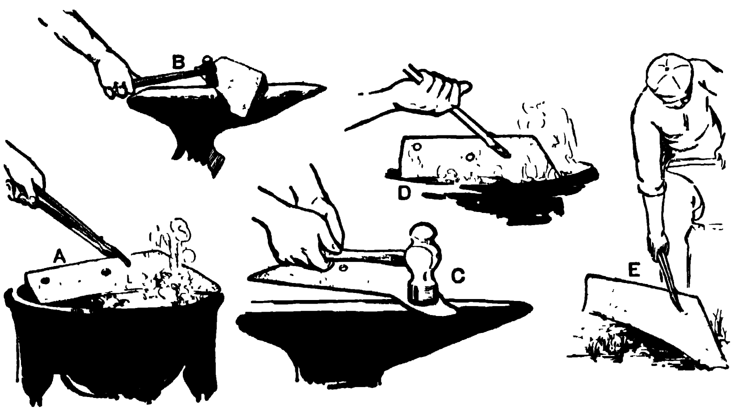


FIG. 15.—Sharpening soft center steel plow shares.

2. Draw with chalk on the floor the outline of a new share. This will serve as a guide in reshaping the worn share.

3. Put the share in the fire as shown in Fig. 15, *A*, and heat it to a dull cherry red, but no hotter. Heat only a few inches of the cutting edge of the share, or just as much as can be hammered at one time. This is accomplished by keeping green coals under the share except for the few inches that are to be heated.

4. Hammer the heated portion of the edge, as shown at *B*, with the bottom of the share flat on the anvil. The share is hammered on the upper side, and is thus drawn down to a keen cutting edge.

Continue this process until all the cutting edge of the share

has been hammered and it coincides as nearly as possible with the chalk outline of a new share.

5. Place the share point in the fire and heat it to a cherry red. Forge it out until it has the proper shape. To determine this, check it with the chalk outline on the floor.

6. Heat the point again and bend it down about $\frac{1}{8}$ to $\frac{3}{16}$ in. To do this, hold the share on the anvil and strike it lightly with the hammer as shown in Fig. 15, *C*. This will give a gradual downward slant to the share point. Do not strike the point where it extends beyond the anvil.

7. Temper or harden the share by drawing it slowly through the fire with the cutting edge down (*D*). The entire share should be heated to a uniform cherry red for about $\frac{1}{2}$-in. back from the cutting edge. When the point and entire cutting edge have reached this heat, withdraw the share from the fire and place it in the ground as shown at (*E*). Let it remain in this position until thoroughly cooled.

SULKY PLOWS

A sulky plow may be defined as a single-bottom wheel plow on which the operator rides. Figure 3 shows a sulky plow.

CONSTRUCTION AND PRINCIPAL PARTS

1. Plow Bottom.—The sulky-plow bottom is made up of the same parts as the walking-plow bottom, namely, the frog, share, landside, and moldboard. The construction of some of these parts in the sulky plow, however, is somewhat different from their construction in the walking plow.

(*a*) *Share.*—The point of the sulky-plow share is bent downward and to the side, to give vertical and land suction, as in the walking plow, but the sulky-plow share has no wing bearing. The reason for this will be mentioned a little later, under "Set of the Sulky-plow Bottom." Figure 16, *a*, shows the point of a sulky-plow share, viewed from the landside. The shares are usually of the quick-detachable type. Bolted shares are not often used.

(b) *Landside.*—The sulky-plow landside (Fig. 16, b) is not as long as the walking-plow landside. These landsides are not furnished with the detachable sole, and the heel of the landside is not reinforced. Long, heavy landsides are not necessary, as will be explained under "Set of the Sulky-plow Bottom."

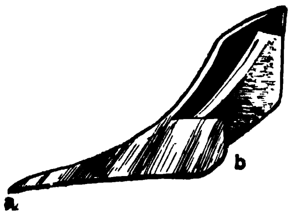


FIG. 16.—Set of the sulky-plow bottom.

(c) *Moldboard.*—The moldboard is similar in construction to that of the walking plow. All of the three general classes of moldboards —breaker, general-purpose and stubble—are furnished on sulky plows.

Set of the Sulky-plow Bottom.—The sulky plow has a one-point bearing, not a three-point bearing like the walking plow. If a sulky plow is placed on a floor and properly leveled (to do this it is necessary to place about a 6-in. block under the high, or land, wheel), when the plow bottom is lowered only the share point touches the floor. The heel of the landside and the wing of the share do not touch (Fig. 16).

Thus when the plow is in operation the point of the share is lower or deeper than the heel of the landside. The heel of the landside does not bear heavily against the bottom or the side of the furrow, as it does in the walking plow. The wheels of the sulky plow carry the weight of the plow bottom and also relieve the landside of much of the side pressure. When a properly adjusted sulky plow is in operation there should be but slight pressure between the landside heel and the bottom of the furrow and also but slight pressure between the landside and the furrow wall.

The sulky-plow share has no wing bearing at the outer edge of the share. This is not required in sulky plows because the wheels support the plow bottom evenly and keep it running steadily.

2. Beam.—The sulky-plow beam is made of high-carbon

steel. It is bolted to the plow bottom in the same manner as described under walking plows.

3. Frame.—The frame (Fig. 17, *a*) is made of flat bars of heavy steel. The wheels and axles are attached to the frame and the plow bottom is hung from it. The frame should be made of tough steel and must be well braced.

4. Bails.—The bottom of the standard sulky plow is attached

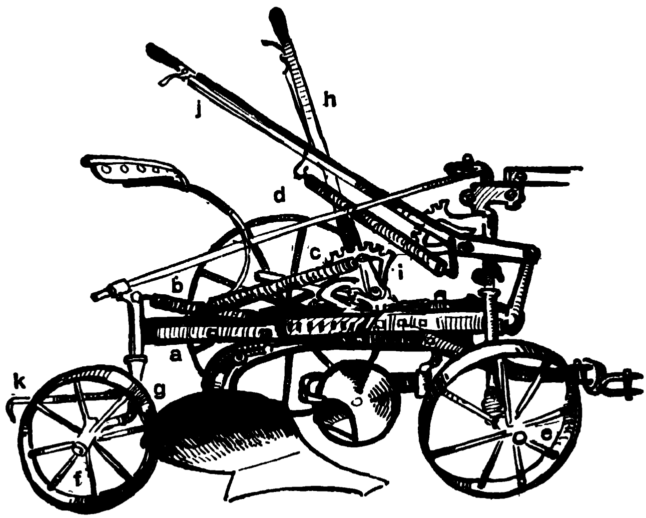


FIG. 17.—Sulky plow.

to the frame by means of the bails which connect the frame and the beam. Sulky plows are made with one or two bails. Each bail has one bearing on the beam and two on the frame. The bails act as cranks to aid in lifting and lowering the plow.

All wheel plows have a decided advantage over walking plows, in that the plow bottom may be easily lifted from the ground at the ends of the field, or when being transported to or from the field. It is not necessary to drag the plow bottom along the ground as is the case with the walking plow.

5. Lifting Lever (Fig. 18, *a*, *b* and *c*).—A foot lever is usually provided for lifting and lowering the plow. This lever is connected between the beam and the frame. Usually two foot pedals are provided to operate this lever, one to lower the plow and the other to raise it. When the plow is lowered the bails rest against the bail stops. These cause the plow bottom to ride steady and make the connection between the frame and the plow bottom more rigid. Figure 18 shows the foot lift lever in the lifted position.

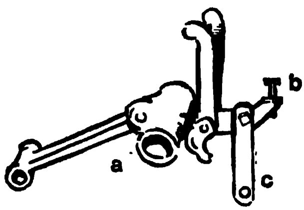


FIG. 18.—Foot-lift lever used on sulky and gang plows.

By means of the set screw (*b*) it is possible to adjust the lifting-lever link (*c*) so that if the plow strikes an obstruction the jar will release the link and the plow will be lifted and pass over the obstruction. This is desirable in plowing stony ground. A plow set in this manner is said to " float."

6. Lifting Springs (Fig. 17, *b* and *c*).—One or more heavy coil springs are connected between the frame and beam. These are called the lifting springs. They aid the operator in raising the plow. The tension of these springs should be tight enough to make lifting as easy as possible, but not so tight as to prevent the plow from entering the ground readily. This adjustment is made with the nut and eye bolt at the end of the spring.

7. Wheels.—Sulky plows are usually provided with three wheels.

(*a*) *Land Wheel.*—Figure 17, *d*, shows the land wheel. It is so named because it runs on the unplowed ground, or " land." It is the largest of the three wheels and is placed on the same side of the plow as the landside.

(*b*) *Front Furrow Wheel.*—Figure 17, *e*, shows the front furrow wheel, which is smaller than the land wheel. It is placed in front of the plow bottom and runs in the open furrow.

(*c*) *Rear Furrow Wheel* (Figure 17, *f*).—The rear furrow wheel is the smallest of the three wheels. It is placed directly

behind the plow bottom and runs in the furrow opened by the latter.

Alignment of Wheels.—The land wheel is set perfectly straight or vertical. It should travel forward in a straight line as indicated in Fig. 19, *c*.

The front furrow wheel is usually set at an angle, as shown in Fig. 19, *a*. This setting resists the side pressure exerted against the moldboard by the furrow. The front furrow wheel is also set to travel slightly toward the land, or is said to lead toward the land (notice the arrow at *a* in Fig. 19). The "lead" of this wheel is controlled by a small lever called the landing lever. This is connected to the axle. This "lead" toward the land aids in maintaining furrows of even width, particularly on hillsides. The landing lever is helpful when the operator is straightening out a crooked furrow. The rear wheel is also set at an angle and is given a "lead" away from the land (notice the arrow at *b*, Fig. 19). The amount of lead is adjustable. This wheel should run a trifle closer to the furrow wall than the landside. The angle at which it is set, the lead away from the land, and its placement close to the furrow wall all help to reduce the pressure against the landside.

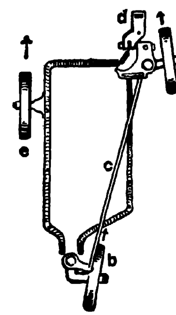


FIG. 19.—Alignment of sulky plow wheels.

8. Axles.—The axles provide a bearing for the wheels and connect the wheels to the frame of the plow. The land-wheel axle is attached to the frame by means of a bracket. The axle passes through one bearing in the bracket and into another bearing on the frame. The land axle is shaped so that the land wheel will set vertically. Axles are made of high-carbon steel. If an axle becomes bent or sprung, the plow is thrown out of adjustment and will not work properly. A bent axle may be straightened by the method used in Job 1 for straightening a steel beam.

The axle for the rear furrow wheel is shaped as shown at *g*, Fig. 17. This sets the wheel at an angle. The axle passes through a bracket on the rear of the frame. It may be raised or lowered slightly by loosening the set screw in the collar through which it passes. This adjustment is used to control the vertical suction of the plow bottom. It should be set so that the heel of the landside is about ½ in. above the floor when the plow is level. (See " Set of the Sulky Plow.")

9. Levers.—Two hand levers are usually provided on sulky plows.

(*a*) The land-wheel lever is attached to the land-wheel axle. It is used to raise or lower one side of the plow. A ratchet with several notches makes various adjustments of this lever possible. The land-wheel lever is sometimes called the leveling lever as it is used to keep the plow level (Fig. 17, *h*).

(*b*) The front-furrow-wheel lever is connected to the front axle and the frame. It is also provided with a lever ratchet. The action of this lever raises or lowers the frame on the front axle. It is sometimes called the " raising lever " or the " depth lever " (Fig. 17, *j*).

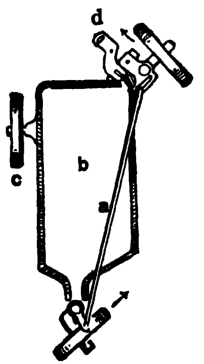


Fig. 20.—Steering device for sulky and gang plows.

Any ordinary change in depth can be made with these two levers. If considerable change in the depth of plowing is required, it may be necessary to change the adjustment on the axle of the rear furrow wheel and to change the position of the bail stops.

10. Steering Device (Fig. 20).—Turning or steering the plow is accomplished by the action of the front and rear furrow wheels. These are connected by means of a long connecting rod (*a*). The pole is bolted on to the pole plate (*d*). This is connected by a bracket to the axle of the front furrow wheel. As the horses are swung to the left these parts take the

position shown in Fig. 20 for a left turn. When turned to the right they are in the opposite position.

11. Clevises (Fig. 21).—A clevis bar (*a*) is used on sulky plows for the horizontal adjustment of the hitch. It has a series of holes which provide a wide range of adjustment. The clevis bar is bolted to the front end of the beam.

A vertical clevis (*b*) is connected to the clevis bar. The various holes in this clevis are used for the vertical adjustment of the hitch.

The evener clevis (*c*) attaches the eveners to the vertical clevis.

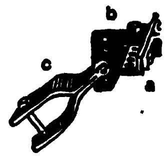


FIG. 21.—Clevises used on sulky and gang plows.

Clevises are made of steel or malleable iron. Steel is the better as these parts are subjected to severe strain.

12. Eveners.—The eveners are made of wood or steel. A three-horse evener is usually furnished with sulky plows.

13. Coulter (Fig. 22, *a*).—A rolling coulter is commonly used with the sulky plow, although some are equipped with a jointer such as that described for walking plows. The work performed by the rolling coulter, however, is quite different from that of the jointer.

The edge of the rolling coulter is sharp. The coulter is placed so that its center, or hub, is almost directly above the share point. The sharp edge cuts the side wall of the furrow. It is usually set to penetrate about half the depth of the furrow, and is placed about $\frac{1}{2}$ in. inside (toward the land) of the landside. Definite instructions for setting the coulter are given on page 41.

The coulter yoke (*b*) is provided with a bearing on which the coulter blade revolves. These bearings should be well lubricated and must be renewed when worn, as a loose bearing causes the coulter to wobble and do poor work.

The coulter shank (*c*) connects the coulter to the plow beam. The lower end of the shank passes through the yoke and is secured by means of a set screw and collar. The upper end, which is square, is bolted to the plow beam with a clamp

(*d*). A wrench is used on this square end to set the coulter toward or from the land.

The use of the coulter improves the plowing. If properly adjusted, the coulter leaves the furrow wall clean-cut and the furrow bottom clean. It also reduces the draft of the plow, as the side wall of the furrow is cut by the sharp, shearing action of the coulter, instead of being torn loose by the shin of the moldboard.

14. Combination Coulter and Jointer (Fig. 22).—The coulter and jointer are often used in combination, as shown in Fig. 22. This is very desirable as the advantages of both are obtained.

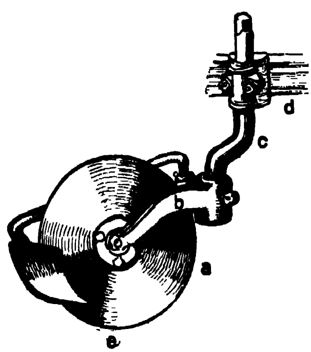


FIG. 22.—Combination coulter and jointer.

The jointer works better when used in combination with the coulter than when used alone. The coulter cuts the surface trash into short lengths so that it will not catch and drag on the jointer but is completely inverted and covered.

The jointer is connected to the yoke of the coulter. It is adjusted so that the point is directly below the coulter hub and just clear of the coulter blade.

15. Pole and Neckyoke.—The pole is bolted to the pole plate (Fig. 19, *d*). Its function is to steer or guide the plow. The neckyoke is attached to the front end of the pole by means of an eye bolt.

16. Weed Hook.—Fig. 23, *a*, shows the location of the weed hook. This is used when plowing under a high surface growth of weeds or a crop of green manure. The use of weed hooks helps to cover surface growth completely.

GANG PLOWS

A gang plow may be defined as a riding plow with two or more plow bottoms. Two-bottom gang plows are used very generally. Fourteen-inch bottoms are the most common size.

The chief advantage of the gang plow is that one man can do nearly twice as much plowing in a day with this plow as he can do with a sulky plow, and more than twice as much as with a walking plow. More horses are necessary to pull the additional plow, but one man can control the work of the two plow bottoms almost as easily as he can control that of one.

CONSTRUCTION AND PRINCIPAL PARTS

The construction of the gang plow and the location and adjustment of the various parts are practically the same as in the sulky plow. Consequently, only the few differences in construction and adjustment will be discussed here.

1. Beams.—The beams are made of steel. They should be well braced both at the front and at the rear of the plow. They must be so designed that there is ample space between them, so that the two plows will not interfere with each other. To accomplish this, one plow is set well ahead of the other. Beam clearance is measured as indicated at *b* in Fig. 23. Throat clearance is measured as indicated at *c* in Fig. 23.

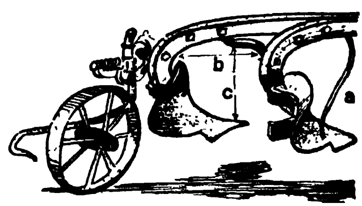


Fig. 23.—Gang-plow beams and bottoms.

2. Landsides.—The landside on the rear plow is similar to that used on the sulky plow. The front plow of the gang has a very short, stub landside. The furrow wall against which this landside would bear is removed by the cut of the rear plow. A long landside on the front plow would prevent the proper turning of the furrow by the rear plow.

3. Alignment of Wheels.—The front furrow wheel is given more lead toward the land, and the rear furrow wheel more lead away from the land, than on the sulky plow.

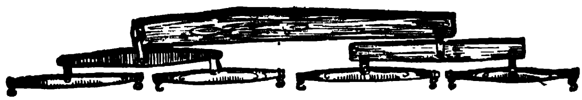
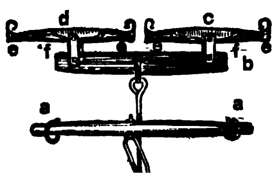


FIG. 24.—Gang-plow eveners "4-horse abreast hitch."

4. Clevis Bar (Fig. 21, *a*).—The clevis bar used on the gang plow extends across the front of both beams. It provides a wide range of horizontal adjustments for the hitch.



5. Eveners.—Four- or five-horse eveners are usually furnished with gang plows. Figure 24 shows one type of four-horse evener. This is known as a "four-horse abreast" hitch, that is, the horses are all in one line. Figure 25 shows a five-horse tandem or "strung-out" hitch. The horses are more easily handled if hitched abreast, but the tandem hitches bring the horses almost directly ahead of the load they pull. This is a distinct advantage as is explained on page 55.

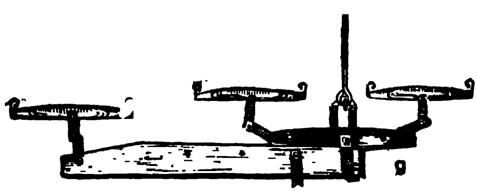


FIG. 25.—Gang-plow eveners five-horse "strung-out hitch."

FRAMELESS RIDING PLOWS

The riding plows described in the foregoing pages are known as " high-lift " plows, that is, the entire plow bottom may be lifted quite clear of the ground. To obtain this high lift a complete frame is necessary.

Riding plows are also built without frames and are then called " low-lift " plows. The axles of the land wheel and front furrow wheel are carried in bearings bolted to the beam. By means of levers these axles serve to raise or lower the point of the plow. The heel of the plow is not lifted by the levers. Both the front and rear furrow wheels are castered so that short, square turning is possible. A turn in either direction may be made without raising the plow from the ground. This type of plow is usually operated without a pole. The direction of pull on the clevis controls the steering of the plow.

TRACTOR PLOWS

Tractor moldboard plows may be divided into two main class:

1. Rigid-beam plows;
2. Independent-beam plows.

The former is now the more widely used. In the rigid-beam plow the beams are bolted together and all the plow bottoms are raised or lowered as a unit; while in the independent-beam plow each beam is free and may be raised or lowered independently. Rigid-beam plows are furnished with from two to four plow bottoms. The lifting mechanism of the rigid-beam plow is simpler than that of the independent-beam plow.

Independent-beam plows are used where sufficient power is available to pull a large number of bottoms. From four to twelve bottoms are commonly used, the number depending upon the amount of power available. Such plows are used on large fields, where long trips back and forth are possible and where there is plenty of room for turning. These plows are made principally for breaking virgin soil.

Each plow is hinged separately to the frame. By means of a hand lever, any one plow bottom may be raised without interfering with the rest. A master lever, which raises all the bottoms at the same time, is also provided.

A power-lift device is operated by the motion of the land wheel, so that the lifting of the plows is not dependent upon hand levers alone.

Each plow bottom follows the contour of the ground independently. This results in even depth of plowing and uniform furrows. The power-lift devices cause the various plows to be lifted in succession, beginning with the one farthest ahead. This means that each plow will plow exactly the same length of furrow. The plows also enter the ground successively. This is necessary where a large number of bottoms are used. If the plows all entered the ground at the same time the forward one would be many feet ahead of the rear one. The same would be true if the plows were all lifted from the ground at the same time. This would leave the ends of the field very uneven.

On rigid-beam plows the plow bottoms do not enter or leave the ground on a line; that is, the forward plow has plowed a little further toward the end of the field than the rear one. The ends of the furrows, therefore, are not exactly even. This is not a serious objection, however, as the irregularity is slight because few bottoms are used on rigid-beam plows.

As rigid-beam tractor plows are much more widely used than independent-beam plows, they will be discussed at some length here. They are built in sizes suitable for use with the popular sizes of tractors (tractors from 8 to 15 draw-bar horsepower). Twelve or 14-in. plow bottoms are commonly used.

CONSTRUCTION AND PRINCIPAL PARTS

In many ways the construction of tractor plows and their various parts and adjustments are very similar to those of sulky and gang plows. Much of the information given about the latter applies as well to tractor plows.

The set of the plow bottom and the adjustment of the wheels, coulters, and jointers of the tractor plow is substantially the same as for a riding plow. The various parts used are also similar. Only the principal differences will be discussed here.

1. Lifting Device (Figs. 26 and 27).—Tractor plows are raised and lowered by means of a "power-lift," which is usually operated automatically by the land wheel. The power of the

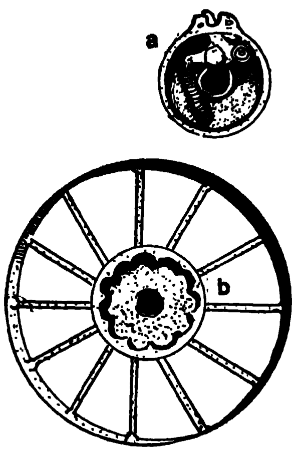


Fig. 26.—Construction of power lift used on tractor plows.

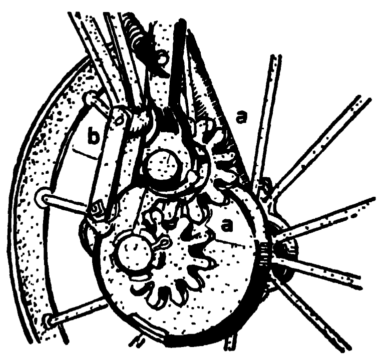


Fig. 27.—One type of power lift used on tractor plows.

revolving land wheel is transmitted, when desired, by a clutch, through chains or gears, to a lifting crank. When the clutch (Fig. 26, *a*) is engaged by means of the roller its power is transmitted to the power crank (Fig. 27, *b*) through the gears (Fig. 27, *a*). The motion of the power crank raises all the plow bottoms evenly from the ground. A trip lever, operated from the tractor seat with a rope or rod, is used to control the power-lift clutch. When the plow is raised the roller (Fig. 26, *a*) enters one of the recesses in the landwheel (Fig. 26, *b*). Then the clutch revolves with the wheel. When the clutch is dis-

engaged the roller is locked away from the recesses and the wheel revolves without driving the clutch.

2. Wheels.—Two-wheel tractor plows are becoming quite common for the two-bottom plow sizes. Three- or four-bottom plows usually have three wheels.

Tractor plows that have no wheels have also been designed and are in use. The plow is carried on the tractor and may be raised clear of the ground (Fig. 7).

3. Draw Bar.—The draw bar on a tractor plow has the

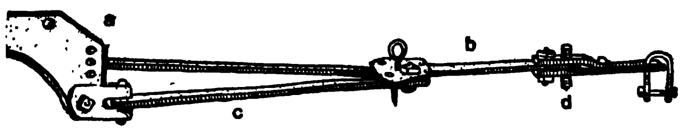


FIG. 28.—Tractor-plow draw bar.

same function as the eveners on a riding plow. It connects the load to the power and must provide means for the correct adjustment of the hitch, both horizontally and vertically. The various parts of the draw-bar connections of a standard tractor plow are shown in Fig. 28, where the vertical adjustment is seen at *a* and the horizontal adjustment at *b*. The hitch adjustments of the tractor plow will be discussed in Job 4, page 54.

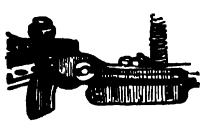


FIG. 29.—Draw bar coupling with spring release.

Some means is usually provided in the draw bar for automatically uncoupling the plow if a rock or other obstruction is struck. This prevents serious damage to the plow and possible injury to the operator of the tractor. Figure 29 shows a spring release. The coupling that connects to the tractor draw bar is held in place by the coil spring. Unusual pressure or a severe jar on the plow will compress this spring to such an extent that the coupling will slip from the draw bar and release the plow.

Figure 28, *d*, shows a wooden break pin in the draw bar, used to accomplish the same purpose.

4. Axles.—Fig. 30 shows how the axles are attached to the beams. Large steel boxes provide bearings for the axles.

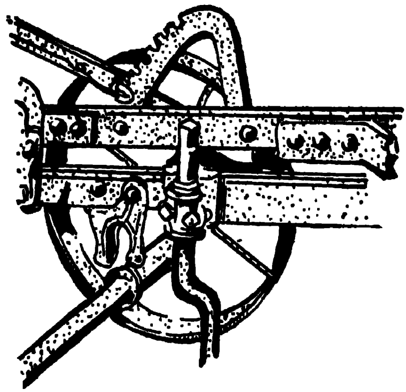


FIG. 30.—Connection of tractor-plow axle to frame.

Because of this method of attaching the axles, tractor plows lift high. The entire bottom lifts clear of the ground, even though the plow is made without a frame.

LABORATORY STUDY NO. 2

To inspect, study, and adjust a riding plow (sulky or gang).

Equipment Necessary.—A riding plow, complete with all parts.

Procedure.

1. Place a 6-in. block of wood under the land wheel. Lower the plow until the share point touches the floor. Level the frame of the plow by means of the leveling lever and the depth lever. Measure the clearance under the heel of the landside (Fig. 16, *b*). This should be about $\frac{1}{2}$ in.
2. Locate the bails and bail stops.
   (*a*) When the plow is lowered, do the bails rest against the bail stops?
   (*b*) How are the bail bearings lubricated?
3. Locate the lifting lever.
   (*a*) Is this a hand lever or a foot lever?
   (*b*) How is the plow set to float?
4. Adjust the lifting springs to the proper tension.
5. Locate and examine the rear furrow wheel and axle.
   (*a*) How may this wheel be adjusted to " lead " away from the land?
   (*b*) Can the frame be raised or lowered on the rear axle?
   (*c*) Is an adjustment provided to move the rear axle (and rear furrow wheel) toward or away from the land?

Note.—On many riding plows, three adjustments are possible at the rear axle:

(*a*) lead of the furrow wheel away from the land;
(*b*) vertical adjustment of frame on the rear axle;

(*c*) horizontal (lateral) adjustment of the rear axle, by means of which the rear furrow wheel is moved nearer to or farther from the land.

6. Locate and examine the front furrow wheel.
   (*a*) How is this wheel adjusted to lead toward the land?
   (*b*) Is this wheel inclined at an angle with the vertical?
   (*c*) On a plow with 14-in. bottoms, how far should the land wheel be set from the landside of the first plow?

7. Adjust the depth of the rolling coulter so that it will cut about one-half the depth of the furrow. To do this, loosen the nuts shown at *d* in Fig. 22 and move the coulter shank up or down as required.

8. Set the coulter about $\frac{1}{2}$ in. to the land. This is done by loosening the nuts at *d*, Fig. 22, and turning the square end of the coulter shank with a wrench. Turn it until there is $\frac{1}{2}$ in. between the coulter and the landside.

9. Examine the hand levers.
   (*a*) What is the purpose of each?
   (*b*) Which lever should be used for leveling?
   (*c*) Which lever should be used for changing the depth of plowing?

10. Examine the clevises.
    (*a*) What material is used in the clevises?
    (*b*) How is the clevis bar attached to the beams?
    (*c*) How many holes are provided for the lateral or horizontal adjustment of the hitch?
    (*d*) How many holes are provided for the vertical adjustment of the hitch?

11. Answer the following questions about the eveners:
    (*a*) Are they designed for a tandem or abreast hitch?
    (*b*) For how many horses?
    (*c*) Of what material are they?

Job No. 3

TO REPAIR A RIDING PLOW (SULKY OR GANG)

Operations Necessary to Perform the Job.

1. Sharpen or replace shares.
2. Replace landside (if necessary).
3. Tighten all parts of plow bottom to secure smooth, even joints.
4. Inspect beams.
5. Replace worn wheel boxes.
6. Adjust bail bearings.
7. Adjust tension of lifting springs.
8. Sharpen and adjust coulters and jointers (if used).
9. Tighten all bolts.
10. Inspect axle brackets. Replace if badly worn.
11. Adjust rear wheel scraper.
12. Cover the plow-bottom parts with a coating of heavy grease. Paint all other parts.

Description of Operations.

1. Examine the share for sharpness and for horizontal and vertical suction. If the share is dull or worn out of shape, sharpen or replace it as described in Job No. 2.

2. Examine the landside for wear, particularly at the heel. Replace it if necessary.

3. Fit the plow-bottom parts carefully. Even joints must be secured between the share and moldboard and between the share and landside. When fitting on a new or resharpened share or a new landside, one may find that it does not make a good joint with the other parts of the plow bottom. One of the surfaces may project beyond the other. This condition may prevent the plow bottom from scouring properly. Shim up the low part with sheets of cardboard.

4. Examine the beams. Remove and straighten as described in Job No. 1 if any are bent.

5. Test all the wheel bearings for wear. If they are badly

worn, new wheel boxes should be put in. Worn wheel bearings cause the wheels to wobble and throw the plow out of adjustment. The wheel boxes are usually held in place in the hub of the wheel by one bolt. Take out this bolt and the wheel box may be driven out and the new one slipped in.

Grease all the wheel boxes liberally before replacing the wheels on the axles.

6. Examine the bail bearings. If the bails are loose in the bearing, the upper half of the bearing may be ground or filed down to make a good fit.

7. Adjust the tension of the lifting springs (see page 28).

8. Adjust the coulters and jointers. Both should be kept sharp. They may be ground on the grindstone or emery wheel.

9. Examine and tighten all bolts on the plow bottom, frame, beam axle brackets, clevis bar, beam braces, etc.

10. Examine the axle brackets and the collars securing the axles to the plow. Tighten the set screws or pins used in these collars. Badly worn axle bearings or brackets should be replaced, as they make it impossible to keep the wheels properly adjusted.

11. Tighten the set screw or bolt holding the rear wheel scraper (Fig. 17, *k*). This should be adjusted so that the scraper centers on the middle of the rim of the wheel. The blade of the scraper should clear the wheel about $\frac{1}{4}$ in.

If the rear furrow wheel becomes caked with mud when plowing, the diameter of the wheel increases. This changes the adjustment and causes the plow bottom to ride on the point, which results in poor plowing.

12. Cover the share, moldboard, coulter, and jointer with grease to prevent rusting. Paint all other parts of the plow, including the pole and eveners.

The directions given above will also apply to the repair of rigid-beam tractor plows, but in addition the following operations are necessary.

13. Take apart the power-lift clutch (Figs. 26 and 27). Inspect these parts carefully. Replace worn parts or weak

springs. Clean out the clutch parts with kerosene. Reassemble the clutch and lubricate it well.

14. Inspect the draw bar and its connections. Replace any worn pins or bolts used in the draw bar. If wooden break pins are used in the draw bar, make up a supply of these pins. If the draw bar has a spring release take it apart and dip the parts in oil to prevent their rusting. Rust sometimes prevents this release mechanism from operating.

LABORATORY STUDY NO. 3

To inspect, study, and adjust a rigid-beam tractor plow.

Equipment Necessary.—A tractor plow, complete with all parts and attachments.

Procedure.

1. Place a 6-in. block of wood under the land wheel. Lower the plow to the floor by releasing the power-lift device. Level the plow and measure the clearance under the heel of the land-side (Fig. 16, *b*).

2. Inspect the adjustment of the coulters.

   (*a*) Is the adjustment correct?
   (*b*) Are the coulters sharp?

3. Inspect the adjustment of the jointers.

   (*a*) Is the adjustment correct?
   (*b*) Are the jointers sharp?

4. Test the tension of the lifting springs.

   (*a*) Are they properly adjusted?

5. Measure the "beam clearance" (Fig. 23, *b*) and the "throat clearance" (Fig. 23, *c*).

   (*a*) Why is it necessary to have ample space at these points?

6. Examine the power lift.

   (*a*) Which wheel operates it?
   (*b*) How is the motion of the plow wheel transmitted to the clutch of the power lift?
   (*c*) How does the motion of the power-lift crank raise the plows?
   (*d*) Is the rear of the plow lifted clear of the ground?
   (*e*) How is the power lift controlled by the tractor operator?

7. Locate and name all the levers.
   (*a*) What is the purpose of each?
   (*b*) Which is used for adjusting the depth?
   (*c*) Which is used for leveling?

8. Examine the tractor draw bar.
   (*a*) How is the hitch adjusted vertically?
   (*b*) How is the hitch adjusted horizontally?
   (*c*) What safety release device is used?

9. Examine the front furrow wheel.
   (*a*) How is it secured to the axle?
   (*b*) Can it be adjusted in or out on the axle?
   (*c*) Determine where it should be set on the axle?
   (*d*) What would be the effect of having this wheel set too close to the furrow wall?
   (*e*) How is this wheel lubricated?

10. Examine the rear wheel (if one is used) and rear axle.
   (*a*) How many adjustments are provided on the rear wheel?
   (*b*) What advantage has a solid rear wheel over an open-type rear wheel?
   (*c*) How is this wheel lubricated?
   (*d*) How is the dust and dirt kept out of the wheel bearings?

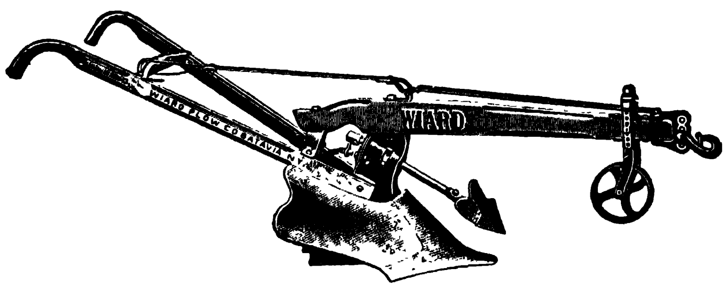
11. Examine the plow bottoms.
   (*a*) What material is used in their construction?
   (*b*) Are the shares bolted or quick-detachable?
   (*c*) Is the share properly shaped?
   (*d*) How does the landside of the rear plow bottom compare in length with the others?
   (*e*) What type of moldboard is used?

12. Study the method of attaching the wheel axles to the beams.
   (*a*) Do the axles pass over or under the beam?
   (*b*) How are the axles held in place in the axle bearings?

HILLSIDE PLOWS

Plowing on steep hillsides often requires a special type of plow because of the difficulty of inverting the furrow when it must be turned uphill. This is necessary half the time if ordinary moldboard plows are used. These turn the furrow to the right, and are, therefore, often referred to as "right-hand" plows.

Figure 31 shows a walking plow designed especially for hillside work. The moldboard may be reversed or swung from one side to the other. On the first trip across the field the fur-



Courtesy of Wiard Plow Co.

FIG. 31.—Hillside or swivel walking plow.

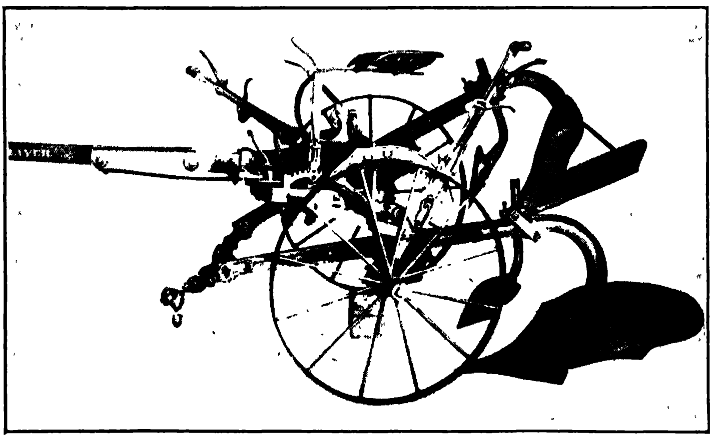
row may be turned toward the operator's right. At the end of the field the plow is reversed, and on the return trip a second furrow is thrown against the first, but this time the furrow is turned toward the operator's left.

For plowing steep hillsides this type of plow is widely used, as all furrows may be thrown downhill. It also makes possible the elimination of all dead furrows (ditches) in the field. Dead furrows are quite objectionable in hillside fields because they form gullies which may cause washing away of the soil.

When the moldboard is reversed at the end of the furrow, the jointer is automatically moved also, so as to be in the proper position for the next furrow. The clevis also is moved over into the proper line of draft for the new setting. The

moldboard is secured in either the right- or left-hand position by a spring-pressure lock.

A two-way sulky plow is shown in Fig. 32. This plow has the same advantages as the hillside or swivel plow. One of its plow bottoms is right-hand, and the other left-hand. Only one of the plows is in action at one time. Fig. 32 shows the left-hand plow in position to turn a furrow, while the right-hand plow is raised. On the return trip the left-hand plow is raised, and the right lowered into the working position. Thus



Courtesy of Oliver Chilled Plow Co.

FIG. 32.—Two-way sulky plow.

the second furrow is laid against the first. In this way an entire field may be plowed without leaving any dead furrows.

The hitch or clevis shown at the front of the plow, shifts automatically from one plow to the other so as to maintain the proper line of draft.

On steep hillsides it is usually necessary to shift the pole slightly toward the land in order to keep the plow cutting a uniform width of furrow. A special lever, called the landing lever, accomplishes this. It acts so as to incline the plow slightly uphill to overcome or offset its tendency to slip downhill.

LABORATORY STUDY NO. 4

(Field Trip)

To study the characteristics of good plowing; to judge plowing.

Good plowing is of fundamental importance to the production of crops. It cannot be done without a thorough understanding of plow construction and the purpose of the various parts. The ability to make the necessary adjustments can be gained only by experience and keen observation. Definite or set rules for plow adjustments cannot always be given. Soil conditions vary to such a degree that a plow properly adjusted for work in one field might not do satisfactory work in another.

The student must first learn to recognize the characteristics of good plowing, in order that his objective may be clearly in mind.

Some of the more important of these characteristics are listed below. The student should understand the meaning of each one thoroughly. These are some of the standards by which plowing is judged in official plowing contests, which are often held in the United States.

The score card that follows indicates fairly well the relative importance of eight necessary qualities of good plowing. A plowed field that has mellow or old ground should be selected for this study. The judging should be done soon after the plowing is completed, as the various features mentioned in the score card stand out better when the plowing is fresh.

	Per Cent
1. Furrows straight from end to end..................	10
2. Back furrow slightly raised, and all trash in it covered.	10
3. Ground thoroughly pulverized from top to bottom of furrow. No air spaces left in plowing............	20
Note.—This rule does not apply to the plowing of sod or new ground.	
4. All trash and surface growth completely covered.....	20

		Per Cent
5.	All furrows of equal depth and width	10
6.	Dead furrows free from unplowed ground	10
7.	Furrow crowns even: level-appearing field	10
8.	Proper and uniform depth in plowing headlands	10

A brief explanation and discussion of each of these eight factors follows:

1. Straight furrows depend to a great extent upon the skill of the driver. A plow that does not penetrate properly, however, may result in crooked furrows even with an experienced driver. Lack of penetration causes the plow to swing to one side or the other and not follow directly behind the power drawing it. Improper hitching gives the same result. Plow hitches and the causes of lack of penetration will be discussed later in this chapter. Crooked furrows make it very difficult to plow out all of the ground in the back furrows, and also result in poor covering of surface growth.

2. Plowing is usually begun in a field by striking out a back furrow. Most moldboard plows are right-hand, that is, they turn the furrow toward the right. The plow is drawn across the field, turning over the furrow to the right. At the end of the field the plow is removed or raised from the ground; the operator turns the implement around and plows back again across the field. The plow turns this furrow also toward the right. In other words, the furrow plowed on the return trip is turned against the one plowed on the first trip across the field.

The furrows thus turned together are referred to as a back furrow. The top or crown of the back furrow (where the two furrows meet) may be slightly higher than other furrow tops. There should be no trash or grass showing through the back furrow.

3. The amount of pulverization depends upon the shape of the moldboard, the speed at which the plow is drawn, and the condition of the soil. The speed is not subject to much variation except with tractor plows. The second or intermediate speed, which gives a forward speed of about 2½ miles per hour,

is the proper one for plowing with most tractors. The first or low speed, which results in less pulverization, must be used where plowing conditions are difficult.

If the correct type of plow bottom is used and the plow penetrates well, good pulverization will be secured.

The plow should leave the soil fine and mellow. Clods and air spaces in the plowing are objectionable.

4. Trash and surface growth should be completely turned under. Weed hooks are helpful in turning under a heavy growth of trash. The combination coulter and jointer, if properly adjusted, will give good covering under most field conditions.

5. Furrows should be of equal depth in all parts of the field. This rule, of course, must be modified in fields where the subsoil is nearer the surface in some parts than in others. Very often only one depth adjustment may be made for the entire field. In some fields, however, it is necessary to change the depth adjustment frequently. Some spots are hard, while others in the same field are soft.

6. A dead furrow is the open ditch or trench which occurs when adjacent furrows are thrown in opposite directions. In large fields where several back furrows are required, dead furrows cannot be avoided.

The dead furrow should be made rather shallow, but no unturned ground should be left in it. Plowing out or finishing up the dead furrows is sometimes difficult. It is especially troublesome if furrows in the main parts of the field are not straight.

7. Careful driving is necessary to secure uniform width of furrows. This is true with both horse-drawn and tractor-drawn plows. The plow must be drawn so that each plow bottom cuts the same width. With gang plows or tractor plows it is necessary to adjust the hitch carefully so that the front plow will cut as wide a furrow as the rear plow (or plows). If it does not cut the proper width the top or crown of this furrow will not be level with the others, and each successive trip across the

field will be marked by this one uneven furrow top. In good plowing, all the furrow tops are of even height.

8. "Headlands," or strips of ground to turn around on, are left at each end of the field. With horse-drawn plows the headlands need not be very wide, but tractor plows require larger ones. A convenient width of headland for a two-bottom tractor is 25 ft. Headlands of this width are left on all four sides of the field. The last step in finishing the field is to plow the headlands. This is usually done by plowing clear around the field without removing the plow from the ground. The ground in the headlands gets packed and hard from the turns made on it when the main part of the field is being plowed. It is sometimes necessary, for this reason, to set the plow deeper when plowing the headlands. All the ground in the headland should be plowed, none missed.

Job No. 4

TO "LAY OUT," "OPEN UP," AND PLOW A FIELD WITH TRACTOR PLOW OR RIDING PLOW

(METHOD USED FOR A RECTANGULAR FIELD.)

Operations Necessary to Perform the Job.

1. Lay out field by making scratch furrows parallel with all four sides of field.
2. Set stakes to mark point of opening first back furrow.
3. Open up back furrow.
4. Change adjustment of front furrow wheel.
5. Adjust vertical and horizontal hitches.
6. Adjust coulter and jointer.
7. Regulate depth of plowing.
8. Plow out from back furrow until plow strip is desired width.
9. Lay out more "lands," as required.
10. Plow out headlands.

Description of Operations.

1. Set the plow to penetrate very lightly. With the plow set just deep enough to make a deep scratch (called the scratch furrow) drive across one edge of the field so as to make a mark parallel with the edge of the field, and about 25 ft. in from the edge. (With horse-drawn plows the scratch furrow may be nearer the edge of the field.)

Make similar marks on all four sides of the field. When completed, the scratch furrow should extend clear around the field, parallel with the sides. The 25 ft. space thus left at each edge of the field is called a "headland." Narrower headlands may be left when using walking plows.

2. Starting where the scratch furrows intersect at one corner of the field, measure or pace in about 60 ft. and set up a stake for a mark. Set up another marking stake opposite the first at the other side of the field 60 ft. in from the corner where the

scratch furrows intersect. These two stakes indicate a straight line across the field.

3. Drop the plow into its working position exactly on one of the stakes. Plow straight across the field toward the second stake.

Lift the plow from the ground when the scratch furrow at the second stake is reached. Turn around to the right, pull back to the scratch furrow, and drop the plow again exactly on the scratch furrow.

The plow should now be in such a position that its return trip across the field will throw the furrows back against those plowed on the first trip. This forms the back furrow.

4. When opening up the back furrow with wheel plows, the front furrow wheel must be raised higher than it is after the back furrow is completed. After this it runs in the bottom of the open furrow, hence it must be set lower.

5. To understand the principle underlying the problem of correct plow hitches, it is necessary to understand the meaning of the expressions " center of power " and " center of resistance."

The " center of power," when two horses are used, is a point midway between the inside traces where they are attached to the collars of the horses. All the power exerted by the horses may be said to be concentrated at this point.

The " center of power " on a tractor may be considered as a point exactly in the middle of the draw bar (at the rear of the tractor).

The " center of resistance " in a single-bottom plow may be considered as an imaginary point about 2 ins. in from the shin of the moldboard. This point is indicated by the cross at *a* in Fig. 11. The " center of resistance " on a two-bottom plow would fall in the center of a line connecting these imaginary points on each moldboard.

A perfect plow hitch is one that causes the " center of resistance " to fall directly behind the " center of power." This means that the plow must be connected to the power (horses or tractor) so that these two points fall in the same line. With

such a hitch the draft of the plow is light. All the power is expended in pulling the plow forward, which is useful work.

If the plow is hitched so that these two points are not in the same line, that is, so that the center of resistance falls to the right or left of the center of power, " side draft " will exist. The expression " side draft " refers to the tendency of these two centers (power and resistance) to work themselves into the same line when the plow is in operation. This tendency must be overcome by the steering of the tractor or the control of the horses. Otherwise either the plow or the power unit (horses or tractor) will move sidewards until the two points are in line.

Power consumed because of side draft is wasted. A perfect hitch is not always possible, however. In many cases the design of the tractors and plows will not permit of a connection that eliminates side draft entirely.

A four-horse-abreast hitch, such as that illustrated in Fig. 24 is always accompanied by a large amount of side draft. The center of power in this case falls in a line which passes through the center of the evener. It will be found that this brings the " center of power " far to the left of the " center of resistance," even with a two-bottom plow. A four-horse, or even a five-horse tandem hitch (Fig. 25) brings the two centers closer together and eliminates much of the side draft. The four-horse-abreast hitch is preferred by many operators, however, because they claim that the horses are more easily handled abreast than in tandem.

Adjustments for bringing the " center of power " and " center of resistance " as nearly as possible into line are made with the horizontal or cross clevis (Fig. 21, *a*) on horse-drawn plows, and by means of the plow draw bar (Fig. 28, *b*) on tractor plows. These adjustments are referred to as the horizontal or lateral hitch. The limiting factor in adjusting the plow hitch is that the front plow bottom must always cut its full width. This means that the plow must be hitched so that the landside of the first plow is about 14 ins. (12 to 16 ins., depending on width of plows used) from the edge of the previous furrow. In all cases

the two centers should be brought as nearly into the same line as possible.

The vertical adjustment of the plow hitch is made by means of the vertical clevis (Fig. 11, *h*) on walking plows, and usually at the rear of the draw bar (Fig. 28, *a*) on tractor plows.

A reference to the point indicating the center of resistance on a walking plow (Fig. 11, *a*) will show that this point is below the surface of the ground when the plow is in operation. It is, in fact, down a little more than half the depth of the furrow.

The center of power, however, is well above the ground. When horses are used it is at their shoulders. With tractors it is at the center of the tractor draw bar, which is from 12 to 18 ins. above the ground.

Because of the fact that the center of power is so far above the center of resistance, there is an upward pull on the plow or a tendency for the power to pull the plow out of the ground. This is overcome by the vertical suction of the plow bottom.

If the connection or hitch between the power and the plow is too low at the plow, the plow will not penetrate properly. There will be so much upward pull that it will not stay in the ground.

If the connection is too high at the plow the plow will be pulled up at the rear end. It will ride on the point, and poor plowing will result.

Securing a proper hitch is sometimes a difficult problem. There are several indications of improper hitching that should be recognized quickly.

Indications of Improper Hitching:

(*a*) Broken or crumbled furrow wall.

(*Note.*—This trouble may also be caused by the coulters being set in too close to the shin of the moldboard.)

(*b*) Dirty furrow bottom.

(This may also be due to a poor coulter adjustment as well as to a poor hitch.)

(*c*) Line of travel of coulters and line of travel of beams not parallel.

Note.—The coulters swing freely. Hence they are always drawn straight forward and always indicate the true line of draft. The horizontal hitching of the plow should be adjusted so that the line of travel of the beams is parallel with that of the coulters.

(*d*) Furrow bottom ragged or "gouged."

This indicates that the vertical hitch is too high at the plow. The plow is pulled up at the rear and is riding on the point.

(*e*) Front furrow wheel "floats."

This means that the wheel rises from the ground and stops revolving.

It is seemingly a queer fact that this may be caused by either too high or too low a vertical hitch. Too low a vertical hitch pulls the plow upward and relieves the front furrow wheel of any weight, with the result that it floats.

Too high a vertical hitch pulls the rear of the plow up. The plow then rides on the plow bottom and not on the wheels, hence the front furrow wheel floats.

(*f*) Uneven furrow crowns.

Sometimes it will be noticed that each alternate furrow crown is low (with two-bottom plows) or every third furrow crown is low (with three-bottom plows). This is caused by the front plow cutting less ground (narrower furrow) than the rear plow. The horizontal hitch must be adjusted to correct this.

If it is noticed that the second or third furrow crowns are high (when using two- or three-bottom plows) this indicates that the front plow is cutting too much ground (too wide a furrow). The horizontal hitch must be adjusted to correct this.

6. Adjust the coulter and jointer (see page 31 and Fig. 22).

7. Regulate the plowing to the desired depth with the depth lever (Fig. 17, *j*). Level the plow with the leveling lever (Fig. 17, *h*).

8. Plow back and forth around the first back furrow. Raise the plow each time the scratch furrow at the ends is reached, turn around to the right, and drop the plow again exactly on the scratch furrow.[1]

9. When the plowed strip has widened until it reaches the

Courtesy of Ford Motor Co.

FIG. 33.—Plowing with a big-base or wide-bottom tractor plow. Notice the complete covering of all surface growth and corn stalks.

scratch furrow from which the distance to the stakes was measured, lay off another strip to be plowed in the same manner. The back furrow for this strip will be 60 ft. from the edge of the plowing. This is 120 ft. from the first back furrow. These strips are called "lands." It is necessary to have more than one strip, or "land," on large fields, as otherwise a great deal

[1] Figure 34 shows the opening of a "land." A big-base or wide-bottom plow is being used, resulting in the complete covering of surface trash. It is this type of plowing that helps to control the corn borer.

of time would be wasted in traveling across the ends of the plowed strips. The " lands " should be as nearly equal in width as possible.

Where each new land is opened a " back furrow " is formed. At the finishing point, a " dead furrow " is formed between two lands.

10. Plow the headlands after all the main body of the field is finished. This may be done by plowing clear around the field without raising the plow from the ground.

Equal space was left on all sides when the field was laid out.

If the trip around the field is started at the scratch furrow, the dirt will be thrown in, and the dead furrow will be left at the extreme edges of the field.

If the trip around is started at the extreme edges of the field, the dirt will be thrown out and a dead furrow will be left where the scratch furrows were.

It is a good plan to alternate each year the direction in which the headlands are plowed.

FIELD TROUBLES

The more common field troubles met with in plowing are listed below with their causes and remedies.

1. Plow Does not Scour.—This means that the soil sticks to the moldboard, instead of shedding or slipping off properly. Such a condition results in very poor plowing. The furrow crowns are not even, and the soil turned over by the plow is not well pulverized but is lumpy and cloddy and full of air spaces.

The principal causes of this trouble are discussed in the paragraphs that follow.

(*a*) *Wrong material in plow bottom.* Sticky or heavy soils or soils with a large amount of clay require soft-center steel mold boards.

In the lighter, sandier soils, moldboards of chilled cast iron scour better than those of soft-center steel. Select the moldboard best suited to the locality.

(*b*) *Improper hitch.* Either the vertical hitch or the horizontal hitch, if improperly adjusted, may cause scouring trouble. The soil must strike the moldboard at the proper angle to shed off properly. Change the hitch so that the plow is drawn straight and runs level.

(*c*) *Soil too wet.* In many localities it is impossible to plow soon after a rain. The soil becomes so sticky that it will not scour off the moldboard. Under these circumstances, plowing must be delayed until soil conditions are suitable.

(*d*) *Rusty moldboard.* Rust on the moldboard is a common cause of this trouble. Soil particles stick to the pits caused by the rust.

The remedy is to scour off the rust. This may be quickly done by plowing in a sandy field if such a field is available. If not, the rust must be scoured off with some abrasive material such as emery.

(*e*) *Soft spots on moldboard.* Moldboards are sometimes faulty, small spots on their surfaces being softer than the adjoining material. Such spots may be detected by drawing a file across the surface of the moldboard. The file will slide over the hard surface easily but will stick slightly on any soft spots. If such spots are found the moldboard must be replaced with a new one.

(*f*) *Coulter or jointer set too close to the shin of the moldboard.* This relieves the shin of the moldboard of practically all soil pressure, with the result that the soil sticks to it. Set the coulter further toward the land.

2. Plow Does not Penetrate Properly.—The causes of this trouble are as follows:

(*a*) *Worn or improperly shaped shares* (no vertical suction).

(*b*) *Vertical hitch too low at the plow.*

(*c*) *Gauge wheel set too low* (walking plows only).

(*d*) *Coulters or jointers set too deep or too far forward.* If set too deep the coulter or jointer carries so much of the weight that it practically supports the plow. If set too far forward it prevents the plow from sucking into the ground. Set the coulters

or jointers just deep enough to cut well through the surface trash, or a little less than half the depth of the furrow.

(*e*) *Levers set wrong.* The depth lever (on front furrow wheel) and the leveling lever (on land wheel) must be set so that the plow can penetrate to the proper depth and run level.

3. Furrow Wall Crumbled or Furrow Bottom Dirty.—This is usually due to the coulters being set too near the shin of the plow. In some soils it is necessary to set them as much as $1\frac{1}{2}$ ins. toward the land. A crumbled furrow wall and a dirty furrow bottom may also result from a poorly adjusted horizontal hitch.

4. Plow Lifts Very Hard.—Tighten the lifting spring.

5. Plow Enters the Ground Very Slowly.—Loosen the lifting spring.

6. Power Lift (Tractor Plows) Does not Operate Properly.—The front furrow wheel, or the land wheel, operates the power lift. In order to lift the plow this wheel must have good traction. It is often provided with small lugs for this purpose. Considerable pressure must be carried on the wheel, however, in order that it may have the necessary grip on the ground.

Anything that lessens the pressure carried on this wheel has a tendency to retard or hinder the action of the power lift. Worn shares or a wrong vertical hitch may lessen the pressure and make the power lift fail to function. Too tight a lifting spring may also cause the trouble, as may also worn rollers or springs in the power-lift clutch.

CHAPTER II

HARROWS

Harrows are very important tillage implements and are a necessary part of farming equipment. They are used for many purposes, on various types of fields, and at different stages in the production of crops. Because the purposes for which they are employed vary so greatly, several kinds have been developed. Only the types most commonly used will be discussed here.

Although harrows may be used under various field conditions, each type is particularly suited for certain definite field work, as will be mentioned later.

SPIKE-TOOTH HARROWS

The spike-tooth harrow is made in sections, each section being between 4 and 5 ft. wide. The number of sections used

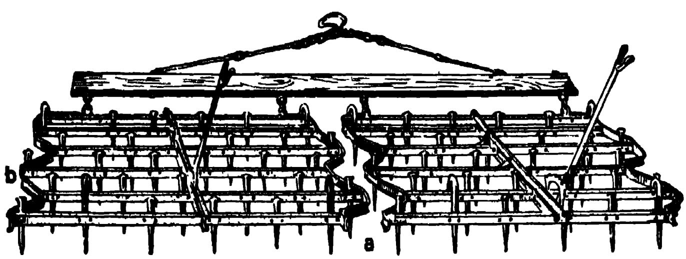


FIG. 34.—Two-section spike-tooth harrow.

depends upon the power available. Figure 34 shows a two-section spike-tooth harrow. The harrow is so constructed that a section can easily be added.

The chief use of the spike-tooth harrow is in preparing the seed bed after the ground has been plowed. The harrow pulverizes the soil well and levels it nicely. The harrow teeth break up clods and lumps left by the plow, compact the soil, and fill up the air spaces. The finely pulverized surface left by the harrow forms a mulch, which retards the evaporation of moisture from the soil.

The spike-tooth harrow is often used for killing weeds. For this purpose it is run over the ground after the crop has sprouted, the teeth being set lightly. Weeds that root near the surface are torn out and destroyed, without injury to the growing crop. The spike-tooth harrow is also used for covering seed that has been broadcast on the surface of the ground.

The spike-tooth harrow is difficult to use on fields that have trash, vines, or stalks on the surface. On such fields the teeth become clogged up with trash which raises them out of the ground and prevents their working properly. Frequent stops to clean the harrow are necessary under such conditions. This implement does not penetrate well on hard, stony fields and it is not particularly good for harrowing sod ground.

The draft of the spike-tooth harrow is light and it accomplishes its work rapidly.

CONSTRUCTION AND PRINCIPAL PARTS

1. Teeth.—The teeth are made of steel and are shaped as shown at *A*, *B*, and *C*, Fig. 35. The head of the tooth is enlarged so that the tooth will not be lost if it becomes loose. All the edges of the tooth are sharpened so that by shifting the tooth a new cutting edge can be obtained. The teeth are fastened to the tooth bars (*A*, *B*, and *C*, Fig. 36), six teeth usually being placed on each bar. A harrow section of five bars would, therefore, have thirty teeth. The teeth are so placed on the five tooth bars that no one tooth is directly behind another. In a 5-ft. harrow section with five tooth bars, every 2 ins. of ground is cut by a tooth.

2. Tooth Bars.—The tooth bars are made of wood or steel. Wooden tooth bars are usually square. Steel bars are made in many different shapes, including round-pipe, flat-bar, channel-bar, and U-bar. The tooth bar shown at *A* in Fig. 36 is of the U-bar type. A round-pipe tooth bar is shown at *B* and a wood tooth bar at *C*. The teeth are attached to the tooth bar.

3. Tooth Clamps.—The tooth clamp fastens the tooth to the tooth bar. Various types of tooth clamps are used. A

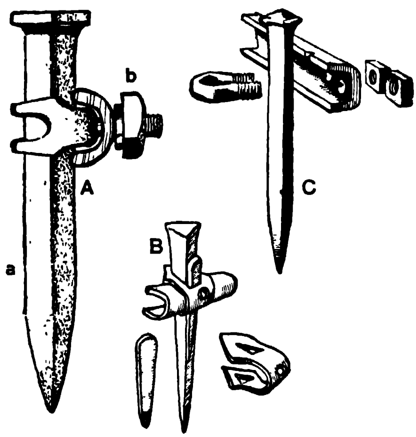


FIG. 35.—Three common types of harrow teeth and tooth clamps.

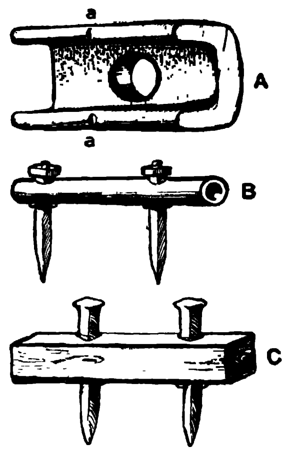


FIG. 36.—Tooth bars.

strong, well-designed tooth clamp is necessary, as there is a severe strain on the teeth when the harrow is in operation and they must be securely fastened and kept tight. The clamp shown at *A*, Fig. 35, is drawn tight by the nut (*b*), which is locked in place by a spring washer. The edge of the tooth is drawn into a notch in the tooth bar (Fig. 36, *A*).

4. Runner Teeth.—Runner teeth, shaped as shown at *A*, *B*, and *C*, in Fig. 37, are placed at the four corners of the section. When the harrow is being transported to or from the field, the teeth are slanted back so that the curved parts of the runner

teeth bear on the ground. This prevents the roads from being torn up and places less strain on the frame of the harrow (Fig. 37, *B*).

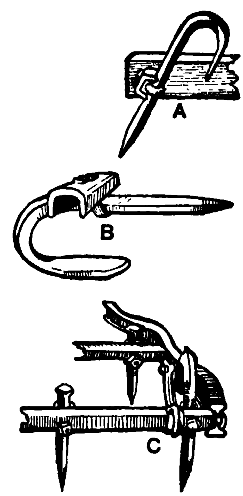


Fig. 37.—Runner teeth.

5. Guard Rails.—The ends of the tooth bars in the harrow section shown in Fig. 34 are closed, and the tooth bars pass through the guard rails (Fig. 34, *b*). Harrows in which the parts are so arranged are called "closed-end" types. Harrows that do not have the ends of the tooth bars closed in this way are "open-end" types. The guard rails strengthen the construction and make the harrow more rigid. They also prevent the ends of the tooth bars from catching on obstructions in the field.

6. Corner Braces.—The corner braces are shown at *C* in Fig. 37. They are placed at two diagonally opposite corners, one brace in front and one behind. Such braces add greatly to the strength of the harrow.

7. Levers.—One lever is usually provided on each section. By means of this the teeth may be set to penetrate more or less

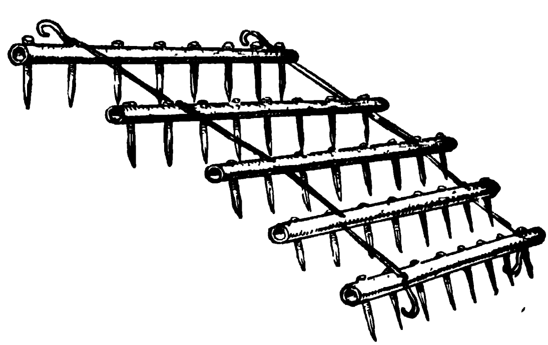


Fig. 38.—Flexible pipe-bar harrow.

deeply, as desired. The flexible pipe-bar harrow, shown in Fig. 38, is to a certain extent adjustable without the use of levers. This type may be drawn from either end. When it is drawn from one end the teeth stand in a vertical position and penetrate deeply. When it is drawn from the other end the teeth slant backward slightly and cut lightly. The latter position is

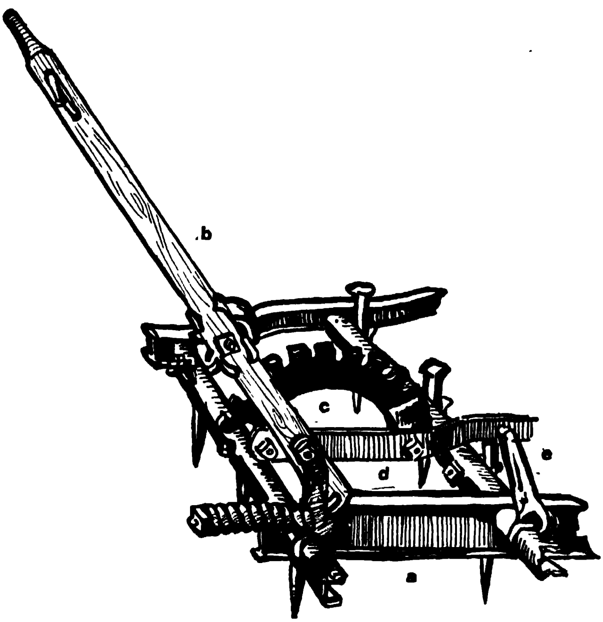


FIG. 39.—Lever used for setting angle of the teeth.

desirable for smoothing and light harrowing, or for killing weeds after the crop is up. Figure 39 shows how the angle of the teeth is controlled by the lever, *b*, shows the lever, and *c* is the lever ratchet. The ratchet has a series of notches in which the lever may be set, thus providing a wide range of adjustment. The lower end of the lever is attached to the rocker bar (*d*). Each tooth bar carries a rocker arm (*e*) which is attached to the rocker bar.

8. Draft Hooks.—The draft hooks, shown at *a* in Fig. 40. are made of steel. One of these is placed at each front corner of every section. The harrow is drawn from these hooks. They must be so constructed that hitching to them is easy and quick, and yet the hitch must be secure and not come loose when the harrow is in use. Some draft hooks have a self-locking device that helps to make a secure connection at this point. The lock may be easily pushed forward and the harrow section released when this is desired. The "pig-tail" type of draft hook is shown at *a*. This is twisted so that there is little chance of a section becoming unhooked in the field, yet it may easily be disconnected when desired.

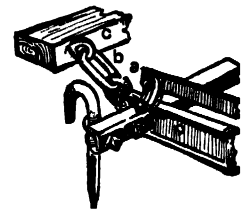


FIG. 40.—Connection of harrow section to evener.

9. Draft Links (Fig. 40, *b*).—The draft links, which are made of steel, connect the eveners to the draft hooks. They are fastened to the eveners by means of the eye bolt shown at *c* in Fig. 40.

10. Eveners (Fig. 34).—The eveners for spike-tooth harrows are made of wood. They are connected to the front corners of all the harrow sections. If properly attached they cause all the sections to pull straight and evenly. Each section is fastened to the evener independently of the others, and the sections are not fastened to each other. This provides great flexibility. One section may be raised to pass over a high place in the field or may drop down into a low place, without affecting the other sections. Combination eveners (Fig. 41, *A*) are used for four-section harrows.

11. Draw Rods and Hitch Ring (Fig. 41, *A*).—These attach the harrow to the tractor or power that draws it. A clevis passes through the hitch ring. The draw rods must be attached to the evener so that the hitch ring will be ahead of the center of the harrow. The draw rods are necessary in order that the power may act along the whole length of the evener. It would

be difficult to make the harrow draw straight and evenly without the wide-spread draw rods. Some harrows have a hitch ring of the type shown at *B* in Fig. 41. This ring may be slipped a short distance in either direction along the chain links that connect the draw rods. In this way the position in which the

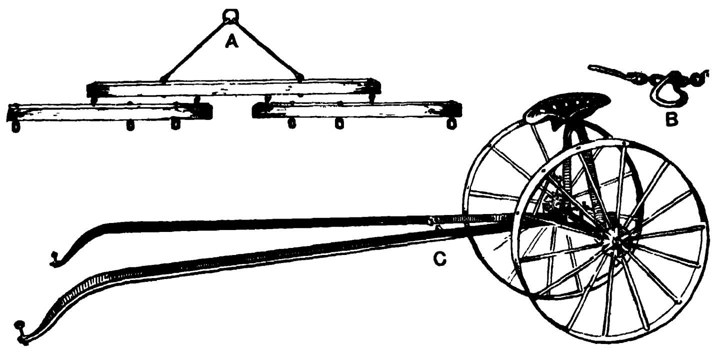


FIG. 41.—Draw rods, hitch rings and harrow cart.

harrows draw best can easily be found. This type is called a "grab ring."

12. Harrow Cart.—A harrow cart, such as that shown at *c* in Fig. 41, is very desirable for use with a horse-drawn spike-tooth harrow. It permits the operator to ride. The long arms reach forward over the harrow sections and are attached to the eveners.

Job No. 5

TO REPAIR A SPIKE-TOOTH HARROW

Operations Necessary to Perform the Job.

1. Remove and sharpen teeth.
2. Straighten tooth bars.
3. Tighten connection between tooth bars and guard rails.
4. Replace teeth and adjust them for depth.
5. Tighten all tooth clamps.
6. Replace drag links (if necessary).
7. Tighten evener bolts and replace if required.
8. Tighten draft hooks.
9. Secure all corner braces.
10. Sharpen or replace runner teeth.
11. Paint all parts.

Description of Operations.

1. Examine the teeth. The front edge of the tooth must be sharp. If it is worn it may be possible to secure a new cutting edge by turning the tooth one-quarter or one-half turn in the tooth clamp. If all the cutting edges are worn, the tooth must be removed and reshaped by hammering on the anvil. If the tooth has been worn down until it is so short that it cannot be set as deeply as the other teeth, it should be replaced with a new one. The points of the teeth wear the most, the tapered part wearing off and leaving a short, blunt point. Sharpening a tooth should restore the original shape. The tooth must be heated in the forge, care being taken not to heat it too much, as this changes the temper of the steel and may weaken the tooth. The tooth should be hammered on the anvil so as to draw it out to a long, tapered point.

2. Straighten the tooth bars, if necessary. A bent tooth bar is easily noticed. It must be removed and straightened by hammering on the anvil. It is not necessary to heat the tooth bar before hammering.

3. Examine the connection of the tooth bar to the guard rail. This connection should be kept tight. In some harrows the tooth bar passes through the guard rail. In others a short extension is bolted or riveted to the tooth bar, this extension passing through the guard rail.

4. Adjust the teeth in the tooth clamps so that they will all penetrate equally.

5. Tighten all the tooth clamps, and replace any broken ones. In some makes of harrows the tooth clamps may slip out of place along the tooth bars, thus changing the spacing of the teeth. See that the tooth clamps are set so that no tooth is directly behind another.

6. Replace the drag links if they are badly worn.

7. Tighten the eye bolts that connect the drag links to the evener. If the hole in the evener, through which these eye bolts pass, has become enlarged, a larger-sized eye bolt should be used. It is necessary that the bolt fill the hole completely, as otherwise the bolt will jerk and churn when the harrow is in operation and will wear the hole larger.

8. Tighten the bolts or rivets in the draft hooks and replace any that are broken.

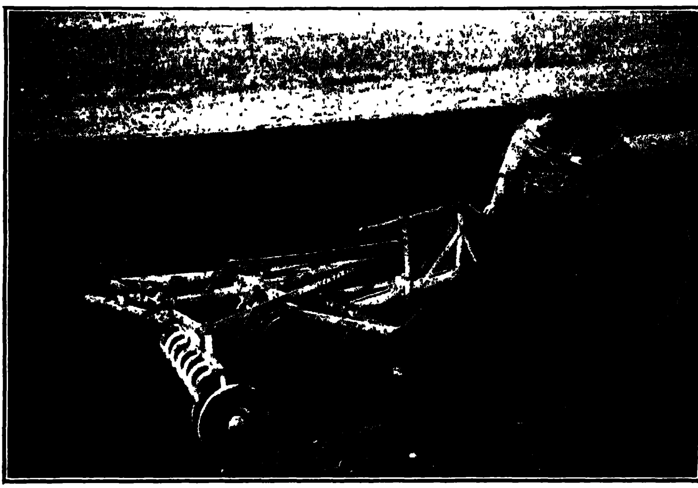
9. Tighten the bolts or rivets that fasten the corner braces. If these bolts or rivets are allowed to remain loose, the effectiveness of the corner brace is lost.

10. Examine the runner teeth. Sharpen the points, as explained in the first part of this job. If the curved part of a runner tooth is badly worn, replace it with a new one.

11. Paint all parts of the harrow, including the eveners. Linseed oil may be used, instead of paint, on the eveners, if desired. Painting preserves the harrow, protects it from rust, and increases the years of useful service obtained from it.

DISK HARROWS

The disk harrow is used extensively for a wide variety of purposes. The sharp, rolling disks penetrate deeply. The disk harrow is an excellent implement for use on ground that has stalks, stubble, or vines, and it is often used on such ground before plowing. The disks cut up the surface trash so that it is all turned under by the plow. This harrow is



Courtesy of Oliver Chilled Plow Co.

FIG. 42.—Tractor disk harrow with tandem attachment.

also very effective on sod ground and on fields where the soil is hard. If necessary, weights can be carried on the harrow to secure deep penetration on hard ground. The action of the disk harrow is not hindered by trash to as great an extent as is that of the spike-tooth harrow.

The disk harrow does not level the ground as well or pulverize it as finely as the spike-tooth harrow. It is, therefore, not classed as a smoothing harrow. For this reason the disk and

spike-tooth harrows are often used together, the spike-tooth being drawn behind the disk. The disk cuts through the lumps, clods, and roots; and the spike-tooth levels and smooths the ground. The combination makes an excellent seed bed.

Because of the deep penetration of this harrow, it is sometimes used instead of the plow. Under certain conditions it is satisfactory to seed in the crop after the ground has been disked, without the use of the plow. The disk harrow is also used for covering seed that has been broadcast, for cultivating orchards, and for mulching the upper surface of the soil to preserve moisture.

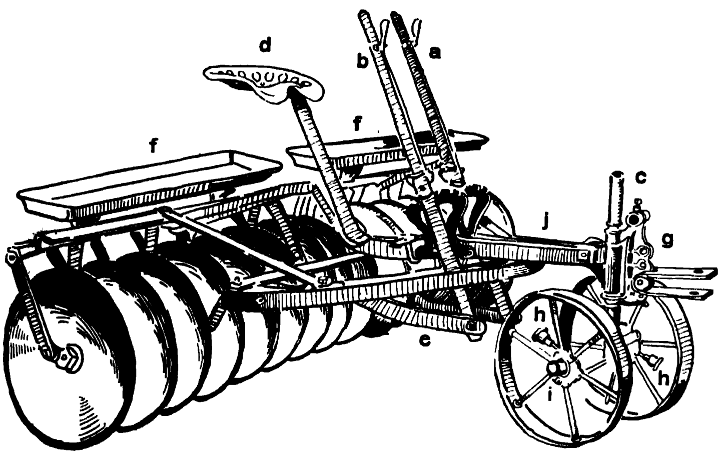


FIG. 43.—Horse-drawn disk harrow with tongue truck.

Sizes.—The disk harrow is made in a number of different sizes, the size being determined by the width of the harrow. The sizes in common use are from 4 to 12 ft. in width, the disks being spaced 6 ins. apart. Thus, an 8-ft. harrow, which is a standard size, has sixteen disks. The disks are 14, 16, or 18 ins. in diameter, 16-in. disks being the most common.

Figure 43 shows a horse-drawn disk harrow of a standard type, with plain disks. Cutaway disks, such as those shown at

A in Fig. 44, or spading disks, such as those shown at *B*, are sometimes used. These disks penetrate more deeply but do not pulverize as well as the plain ones. They are particularly good for work on stony ground. The plain disk, however, is used to a much greater extent than either of the other types.

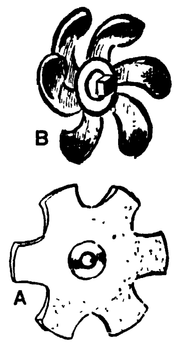


FIG. 44.—Cutaway and spading disks.

Figure 42 shows a tractor disk harrow, with a tandem attachment. The ground is worked twice in one operation. Tandem attachments are also furnished for horse-drawn disks and may be used to good advantage if sufficient power is available to draw the extra load. The front disks are set to throw the soil outward, and the rear disks to throw it inward.

CONSTRUCTION AND PRINCIPAL PARTS

The disks are assembled in sections, which are called gangs or disk gangs. Figure 46 shows two gangs. The right gang throws the soil toward the right; the left gang throws it toward the left. There is an equal number of disks in each gang. All the disks of each gang revolve together as one unit. The two gangs, however, are not connected with each other.

Tractor disk harrows or horse-drawn harrows with a tandem attachment have four disk gangs (Fig. 42).

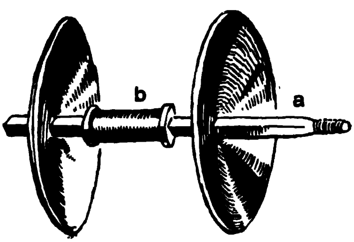


FIG. 45.—Disks, arbor bolt and spacing spool.

1. Disks.—The disks are concave in shape, the amount of concavity usually being about $1\frac{1}{2}$ ins. This is referred to as the " dish " of the disk. The dish of the disk increases the penetrating and pulverizing ability of the harrow. The disks are made of high-grade steel. A long bolt (Fig. 45, *a*)

passes through the square hole in the center of the disk. This bolt holds the disks securely in their places in the disk gang.

The disks are sharpened by grinding. The edge is ground on the back or convex side, to an abrupt beveled edge. The edge should not be ground thin or it will be too weak to stand the severe strain of field work.

2. Main Frame.—The main frame (Fig. 46, *a*) is made of

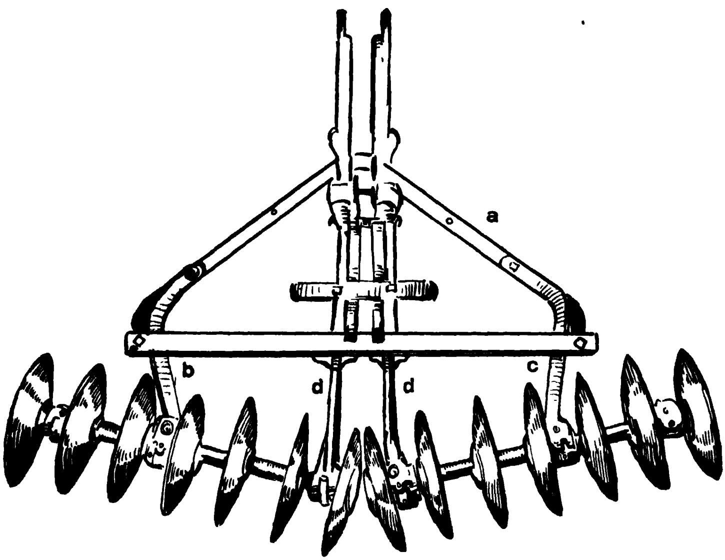


Fig. 46.—Connection of main frame to disk gangs.

steel. The rear end of the frame is connected to the disk gangs, and the front end to the power which draws the harrow. The frame also serves as a base to which other parts are attached. All the levers are attached to the frame. A tongue truck (Fig. 43, *c*) supports the front end of the frame on horse-drawn harrows. The driver's seat (Fig. 43, *d*) is also carried by the main frame.

3. Draft Links.—The draft links, which are made of steel, (Fig. 46, *b* and *c*) connect the outer ends of the main frame to

the disk gangs. The couplings which attach the draft links to the disk gangs are slotted so that the draft links pull in a direct line under all settings of the disk.

4. Lever Bars.—The lever bars (Fig. 46, *d*) connect the inner ends of the disk gangs to the frame. These lever bars are moved by means of the angling levers (Fig. 43, *a* and *b*). When the lever bars are pulled forward as far as possible, the disks are all in a straight line. In this position they are transported to and from the field. With the lever bars moved as far back as possible, the disk gangs take up the angle shown in Fig. 46. This is the greatest angle at which the disks may be set; in this position the harrow penetrates most deeply. The harrow may be set at any angle between these two extremes, depending upon the type of work to be done. For light work, where deep penetration is not necessary, the angle of the disk gang is decreased.

5. Levers.—(*a*) *Angling Levers.*—All harrows are provided with angling levers. These are shown for a horse-drawn harrow at *a* and *b* in Fig. 43. The angling device used on most tractor harrows allows the tractor operator to set the angle of the four disk gangs without leaving the seat of the tractor (Fig. 42).

(*b*) *Pressure Levers.*—Some disk harrows are provided with a special pressure lever, often called a third lever. This is shown at *d* in Fig. 47. It is mounted on the main frame. By means of it, a downward pressure is placed on the lever bars. As these lever bars are attached to the inner ends of the disk gangs, this downward pressure causes the inside disks to penetrate more deeply. In field operation there is a tendency

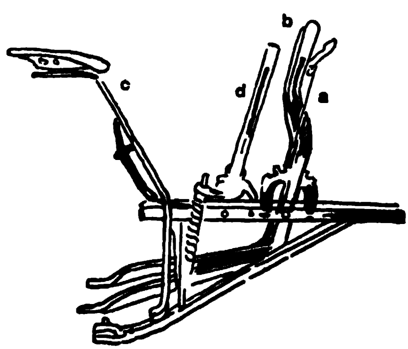


FIG. 47.—Disk-harrow levers.

for the inside disks to cut less deeply than the outside ones. This is overcome by the adjustment of the third lever. Figure 51, *d*, shows how this same pressure adjustment is made without the lever. Here an adjustable snubbing block is used, the lever bars passing through slots in this block. Setting the block down puts more pressure on the inner disks and causes them to penetrate more deeply. The pressure on the inside disks should be regulated so that they all penetrate evenly.

6. Arbor Bolts (Fig. 48, *a*).—One long bolt holds all the disks of each gang in place. This is called the arbor bolt. It is square and passes through the square holes in the disks. Because of this square shape, the disks cannot turn around *on* the arbor bolt but turn *with* it.

A lock washer or special locking device is used to prevent the arbor bolt from coming loose (Fig. 48, *b*).

7. Bumpers (Fig. 48, *c*).—When the harrow is in operation the pressure of the soil tends to force the front gangs together at the center. To prevent the inside disks of the front gangs from rubbing against each other, large concave washers are used. These are called bumpers and are shaped to fit the disk. The bumpers rub together and prevent the inside disks from touching each other. The head of the arbor bolt fits into the large square in the center of the bumper, as shown at *c*.

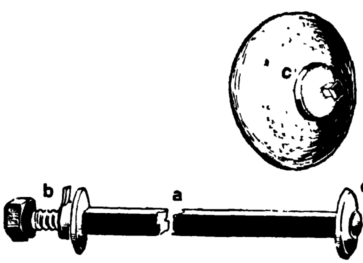


FIG. 48.—Arbor bolt and bump

Well-designed bumpers prevent the disks from rubbing each other at any angle at which the disk gangs are set.

8. Spools (Fig. 45, *b*).—The disks are spaced at 6-in. intervals along the arbor bolt. They are held this distance apart by means of the spools. The arbor bolt passes through the square hole in the center of the spools. The ends of the spools are

shaped to fit the disk. When the nut on the end of the arbor bolt is drawn tight, the disks and spools draw tightly together. As long as the arbor bolt is properly tightened, these parts revolve together as a single unit.

9. Disk Bearings.—Two of the spools on each disk gang are used as bearings between the revolving arbor bolt and the stationary couplings to which the main frame is connected. The construction of a disk bearing is shown in Fig. 49, the upper half of the bearing is shown at *a*, the bearing spool at *b* and the lower half of the bearing at *c*. Each half of the bearing is lined with a wooden bushing (*d*), which is made of hard wood, specially treated for this purpose. The wooden bushings are easily replaced when worn. One of them has a hole drilled through it, thus allowing grease to pass through the bushing on to the revolving bearing spool. Figure 50 shows the bearing assembled with grease cup (*c*) and connecting slot (*d*) for the draft link.

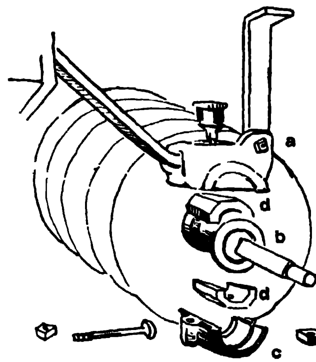


FIG. 49.—Construction of disk bearings.

Disk bearings must be well lubricated. This is difficult because the revolving disks cover them with dust and grit. On many harrows the grease cups are hard to reach, and for this reason are not turned down as often as necessary. The threads on the grease cups often become crossed or damaged so that the grease-cup caps do not turn down properly. A few manufacturers of disk harrows provide roller bearings for the disk gangs.

10. Bearing Standards (Fig. 50, *e*).—The bearing standards are upright bars which extend upward from the disk bearings. They are usually made of steel. The lower end of the standard is usually bolted to the top half of the bearing. In some har-

rows the top half of the disk bearing and the standard are made in one piece. The gang frame is attached to the bearing standards.

11. Gang Frames (Fig. 50, *f*).—One gang frame is provided for each gang of disks. In some harrows it is made of a single piece of angle iron as shown at *f*, or it may be a rectangular frame, closed at the ends. It is bolted to the bearing standards. The weight boxes and the scraper assembly are connected to it.

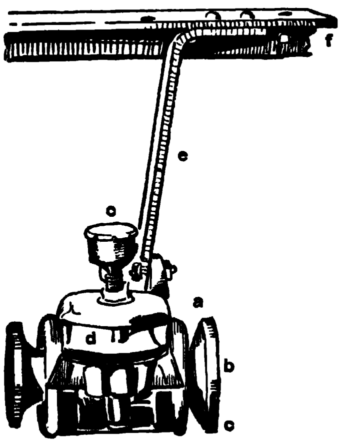


FIG. 50.—Disk bearing assembled.

12. Weight Boxes (Fig. 51, *e*).—On very hard or sod ground or where it is desirable to have the harrow penetrate deeply, it is often necessary to add weights to the harrow. The weight boxes are provided to carry such weights. Sacks filled with sand, rocks, or other heavy material are used as weights. The weight boxes are bolted to the gang frames by means of the supporting casting shown at *g* in Fig. 51. The rectangular gang frame is itself suitable for carrying the weights, so that harrows with this type of gang frame need no additional weight boxes.

13. Scraper Assembly (Fig. 43).—One scraper is provided for each disk, to keep the disk clean and prevent its becoming clogged up. The scrapers are particularly useful on wet, sticky fields. They are attached to a bar or connected directly to the gang frame. The picture of the disk harrow in the field, Fig. 42, shows clearly the location of the scrapers.

On horse-drawn harrows, where the operator rides on the implement, a foot lever (Fig. 51, *g*) is connected to the scraper bar. By moving this the operator causes the scrapers to move from the center to the outer edge of the disk, thus keeping the

entire surface clean. The scrapers are returned toward the center of the disks by a coil spring on the scraper bar. The tension of this spring is usually adjustable.

The scrapers are made of steel and are easily replaced when worn or broken. They are usually adjustable and should be set so that they will just clear the disks when the harrow is in operation. A stop is provided for the foot lever so that the scrapers cannot be pushed off the outer edge of the disk.

Tractor disk harrows do not have levers for adjusting the

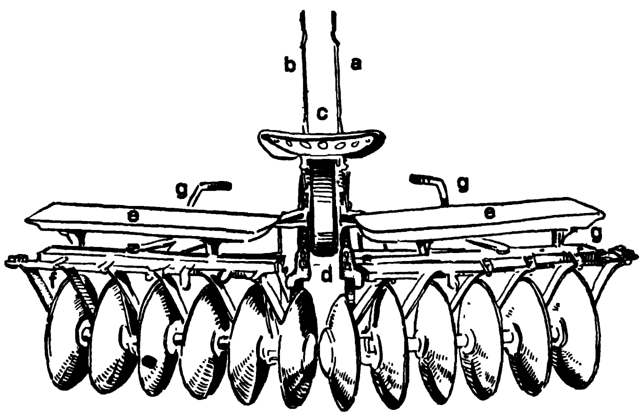


FIG. 51.—Horse-drawn disk harrow. (Rear view.)

scrapers because the operator does not ride on the harrow. The scrapers are set in a fixed position, which may be changed, however, if necessary. In general, the scrapers should be set about 1 in. from the outer edge of the disk. If they are set too close to the edge they may be carried off. The end of the scraper should be set so that it just clears the surface of the disk when the harrow is in operation.

14. Tongue Truck (Fig. 43, *c*).—Horse-drawn disk harrows usually have a tongue truck to support the front end of the main frame. This weight would otherwise be carried on the necks of the horses. Tractor disks are not equipped with

tongue trucks as the weight is easily carried on the draw bar of the tractor, and a tongue truck is not necessary. A draft iron and vertical clevis (Fig. 43, *g*) are provided to make the hitch adjustable. The wheels of the tongue truck should be well lubricated. Grease cups are usually provided for this purpose. The hub cap (Fig. 43, *i*) serves as a grease cup on some tongue trucks.

15. Center Tooth.—On horse-drawn harrows a center tooth is often used. This cuts out the ground left between the center of the two front disk gangs.

16. Stub Pole (Fig. 43, *j*).—Both horse-drawn and tractor disk harrows are furnished with a short or stub pole. This is usually built into the main frame. The tongue truck is connected to the under side of the stub pole, and the vertical clevis (*g*) is also bolted to it. Wooden stub poles are sometimes used but steel ones are more common.

17. Long Pole.—Horse-drawn disk harrows may be purchased without the tongue truck. In this case a long pole is used. As this causes the weight of the main frame to be carried on the horses' necks, it is not in common use. On horse-drawn harrows equipped with a tongue truck, and on tractor harrows, a long pole is not necessary. It is possible to use both a stub pole and a long pole on horse-drawn harrows, but this combination is not frequently employed. In this case the long pole serves for steering only. It supports none of the weight as this is all carried on the tongue truck, but it makes the wheels of the tongue truck run more steadily.

The most common equipment for horse-drawn harrows, however, is that shown in Fig. 43, the tongue truck and stub pole. The direction of pull on the vertical clevis steers the harrow very satisfactorily.

18. Eveners.—The eveners for horse-drawn harrows are made of wood or steel. The eveners are attached to the tongue truck by means of the clevises shown at *g* in Fig. 43. Two-horse, three-horse, or four-horse eveners may be obtained.

19. Transport Trucks (Fig. 52).—It is very desirable to use transport trucks when drawing the harrow to or from the field or when moving it along the road. The large hooks (*b*) are hooked under one of the disk spools, and the latch (*a*) fastens over the weight box or gang frame. The transport trucks may be quickly put on or removed without the use of any tools. They protect the edges of the disks and prevent the cutting up of roads.

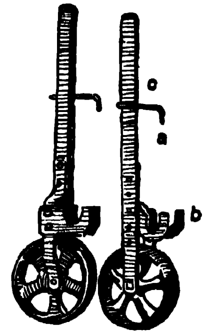


FIG. 52. **Transport trucks for disk harrow.**

One transport-truck wheel is necessary for each disk gang. A harrow with a tandem attachment, therefore, would require four transport-truck wheels.

LABORATORY STUDY NO. 5

To inspect a disk harrow, and locate and study the various parts.

Equipment Necessary.—Complete disk harrow (with tandem attachment, if possible).

Procedure.

1. Count the number of disks in the front disk gangs and determine the width of the harrow.
2. Measure the diameter of the disks.
3. Determine as nearly as possible the amount of "dish," or "concavity," of the disks.
4. What type of disk is used: plain, cutaway, or spading?
5. Locate the bumpers and measure their diameter.
6. Locate the arbor bolt and describe the means used for securing the arbor-bolt nut.
7. Take off the lower half of one disk bearing; examine all parts of the bearing carefully and answer the following questions:
   (*a*) What material is used in the bearing bushings?
   (*b*) How are the bearings lubricated?
   (*c*) How is the bearing standard connected to the bearing?
   (*d*) How are the draft links and lever bars connected to the bearings?
8. Locate and study the construction of the gang frames and answer the following questions:
   (*a*) What material is used in the gang frames?
   (*b*) Is the gang frame an angle-bar or a closed-end type?
   (*c*) How is the scraper assembly connected to the gang frame?
   (*d*) How are the weight boxes connected to the gang frame?
   (*e*) How are the gang frames connected to the bearing standards?

9. Locate and study the construction of the scraper assembly, and answer the following questions:

(*a*) How may a broken scraper be replaced?
(*b*) Can the scrapers be adjusted on the scraper bar?
(*c*) Is the connection between the scraper bar and the gang frame adjustable?
(*d*) Is there a foot lever for operating the scrapers?
(*e*) What means is used to prevent the scrapers coming off the outside edge of the disks?
(*f*) Is there a coil spring on the scraper bar? If so, what is its purpose, and how is it adjusted?

10. Examine the main frame. Is it made of channel-bar, angle-bar, or flat stock?

11. How is the stub pole attached to the main frame?

12. Study carefully the construction of the tongue truck and answer the following questions:

(*a*) How is it attached to the stub pole?
(*b*) How are the wheels lubricated?
(*c*) Is there an adjustment provided so that the stub pole may be raised or lowered where it is connected to the tongue truck?
(*d*) Is the tongue truck provided with a vertical clevis so that the hitch is adjustable?

13. Study the action of all the levers and state the purpose of each.

14. Study the construction of the tandem attachment (if any is used) and answer the following questions:

(*a*) In which directions do the disks of the rear harrow throw the soil?
(*b*) Are the disks of the tandem attachment placed so that they trail exactly behind the front disks, or are they centered between the front disks?
(*c*) How is the angle of the disks adjusted?
(*d*) Are bumpers necessary on the center disks of the tandem attachment?

Job. No. 6

TO OVERHAUL AND REPAIR A DISK HARROW

Operations Necessary to Perform the Job.

1. Test disk bearings for wear. Disassemble disk gangs and replace bushings.
2. Sharpen disks.
3. Straighten arbor bolt.
4. Reassemble disk gangs.
5. Tighten bolts and rivets in disk-gang frames.
6. Repair and adjust scrapers.
7. Tighten bolts or rivets in stub pole.
8. Repair and adjust levers and snubbing block.
9. Tighten bolts in weight boxes.
10. Repair tongue truck.
11. Repair or replace evener parts.
12. Paint all parts (except disks). Cover disks with a coating of heavy grease.

Description of Operations.

1. Test the disk bearings for wear. To do this, stand with the legs astraddle the disk gang. Grasp the gang frame directly above the bearing to be tested, and jerk the frame up and down. If the frame moves without lifting the disk gang, the bearing is worn. Remove the grease cup and take out the bolts holding the halves of the bearing together. Disconnect the draft links and lever bars from the bearings. Pull the halves of the bearing apart. Take out the old bushings and wash the grease and dirt off the bearing spool and the halves of the bearing. Fit in new wooden bushings, seeing that they fit down into their place properly. Clean the grease cup and tube and test it to see that grease is forced through the tube easily. These parts should not be put back in place until after the disks have been removed and sharpened.

Test all the disk bearings in the same manner, and replace the bushings wherever necessary.

2. Sharpen the disks. To do this it is necessary to take the disks off the arbor bolt. Take off the nut on the end of the arbor bolt, and remove the first disk. Then remove the first disk spool and the second disk. It is well to lay the disk spools aside in the order in which they are taken off, as the two bearing spools are different from the others and must be put back in their proper places. The disks are sharpened by grinding. They are of highly tempered steel and must not be ground too fast or the heat set up will change their temper. They are ground to a cutting edge on the back or convex side. The edge should not be made too thin as this will cause it to chip out easily. It is well to finish grinding all of the disks of one gang, and then reassemble them, before starting another gang. In this way fewer parts are left lying about and there is less confusion.

3. Examine the arbor bolt. If, as often happens, the arbor bolt has become bent, it may be straightened by hammering it on the anvil. It is not necessary to heat it.

4. Reassemble the disks on the arbor bolt. Space them properly with the disk spools. Be sure that the bearing spools are in the correct position on the disk gang; this is between the disks where the draft links and lever bars are to be connected. Put the locking device or washer on the end of the arbor bolt and tighten the nut well. Test the gang to see if it is all tight. To do this, turn any one disk. It should cause all the other disks to turn with it. The whole gang should turn as a unit. If one disk can be turned even slightly without moving the others, it means that the arbor bolt is too loose. Complete all the work on one disk gang before disassembling another.

5. Examine the gang frame. Tighten the bolts or rivets that connect it to the bearing standard. Put in new bolts or rivets, if necessary, large enough to fill the holes snugly.

6. Examine the scrapers and replace any that are broken or badly worn. Adjust all the scrapers so that they just clear the surface of the disk when they are in the working position

(about 1 in. from the outer edge of the disk). In most harrows the scrapers may be adjusted where the scraper bar connects to the gang frame, or each scraper may be adjusted separately where it is attached to the scraper bar. Examine the foot lever (if any) and adjust the foot-lever stop so that the scrapers cannot be pushed off the outside edge of the disk.

7. Tighten the bolts or rivets that connect the stub pole to the frame.

8. Examine the levers. Oil the lever latches to prevent rust. See that these parts act freely. Operate the angling levers or angling device, to make sure that they are working properly. Examine the lever bars and straighten them if they are bent out of shape. Tighten the bolts that connect the snubbing blocks (Fig. 51, *d*) to the main frame.

9. Tighten the bolts that secure the weight boxes (if any) to the gang frame.

10. Jack up the front end of the stub pole to take the weight off the tongue truck. Rock the wheel on the axle to determine the amount of wear at this point. Remove the wheel and examine the axle and the inside of the wheel box or hub. Either the axle or the hub may be worn. The wheel hub is usually removable, and a new hub may be put in or a new axle used if necessary. Grease the axles well and replace the wheels.

11. Examine the eveners for cracks or splits in the wood. See that the single-tree hooks are tight on the single-trees. The bolts holding the metal straps should completely fill the holes through the evener. If the holes have become enlarged, it is best to use a larger bolt. To do so it may be necessary to ream out or drill the hole in the metal to a slightly larger size.

12. Paint all the wood and metal parts of the harrow except the disks. This will prevent rust and make the implement last much longer. The disks should be completely covered with a thick coating of heavy grease.

SPRING-TOOTH HARROWS

The spring-tooth harrow is especially useful for harrowing hard or stony ground. The strong steel teeth are not damaged or broken by striking obstructions. They pulverize the ground fairly well and can be set to penetrate deeply.

Another important use of the spring-tooth harrow is in destroying noxious grasses or weeds that are propagated by roots. The deeply penetrating teeth tear out the roots and bring them to the surface, where the sunlight destroys them.

Cultivating alfalfa is also done advantageously with the spring-tooth harrow. Special teeth are sometimes used for this purpose (Fig. 53).

FIG. 53.—Special tooth for cultivating alfalfa.

Sizes.—The spring-tooth harrow is made in sections, as is the spike-tooth harrow. Each section usually contains about eight teeth and cuts a width of about $2\frac{1}{2}$ ft. The number of sections used can easily be changed to suit the power available. The sections are hinged together at the center. This causes them to pull evenly, and yet permits each one to follow the contour of the ground.

CONSTRUCTION AND PRINCIPAL PARTS

1. Teeth (Fig. 54 and Fig. 55).—The teeth are made of spring steel. They are long and bent nearly into a complete circle. The ends are sharpened and are usually from $1\frac{1}{2}$ to $1\frac{3}{4}$ ins. in width. Some spring-tooth harrows are furnished with double-pointed teeth (Fig. 54). These points are removable, and can be reversed so that a double wearing surface is obtained.

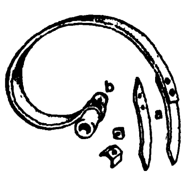


FIG. 54.—Spring tooth with reversible point.

The teeth are so placed in the section that they do not trail each other. In the standard section with eight teeth, the teeth fall between 3 and 4 ins. apart. Because

of the width of the teeth, this spacing harrows the ground very completely.

2. Tooth Bars (Fig. 55 and Fig. 56).—The tooth bars, which carry the teeth, are usually made of steel. Several different shapes of tooth bars are used by the manufacturers. A round type of tooth bar is shown in Fig. 55. Channel-steel (Fig. 56) and flat-steel tooth bars are also used. Wooden tooth bars are used to some extent. The tooth bars on the spring-tooth harrow are shorter than those on the spike-tooth harrow. The spring teeth penetrate deeply, and, as the harrow is commonly used on rough or hard ground, the tooth bars must be strong and well supported at the ends.

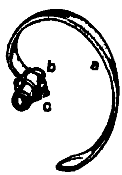


FIG. 55.—Round pipe tooth bar and tooth clamp.

3. Tooth-bar Standards (Fig. 56, *b*).—The tooth-bar standards support the ends of the tooth bars. They are usually riveted to the frame. The ends of the tooth bars pivot in the tooth-bar standards to provide for setting the depth to which the teeth are to penetrate. The ends of the tooth bars are attached through the standards so as to turn freely and also to act as cross braces to hold the frame together.

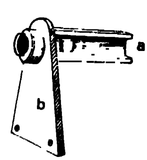


FIG. 56.—Connection of tooth bar to tooth-bar standard.

4. Tooth Clamps (Figs. 55 and 57).—The tooth clamps attach the teeth to the tooth bar. The tooth clamp shown in Fig. 57 is composed of a malleable clamp, a steel clip, and a bolt.

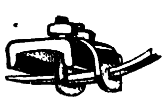


FIG. 57.—Channel steel-tooth bar and tooth clamp.

The device shown in Fig. 55, *c*, consisting of a steel clip and a steel retainer, is used with round steel tooth bars.

5. Frame (Fig. 58, *A* and *B*).—At *B* is shown a harrow frame of angle iron. The frame is of one piece, bent so as to enclose the front and each side of the harrow section. It must be strongly

constructed, as all strains to which the harrow is subjected are transmitted to it. The harrow is drawn directly from the frame. In some harrows the sides of the frame carry a runner beneath them (*A*). This runner, or shoe, is detachable and can be renewed when worn. The runners protect the frame and carry the weight of the harrow when it is being transported to or from the fields. Three runners are provided for each section, one in front and two at the rear corners. The frame is the base of the entire implement, and to it all parts are connected either directly or indirectly. At *A* in Fig. 63 is shown a frame made of a flat steel bar.

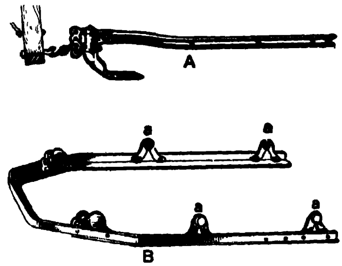


FIG. 58.—Spring-tooth harrow frame.

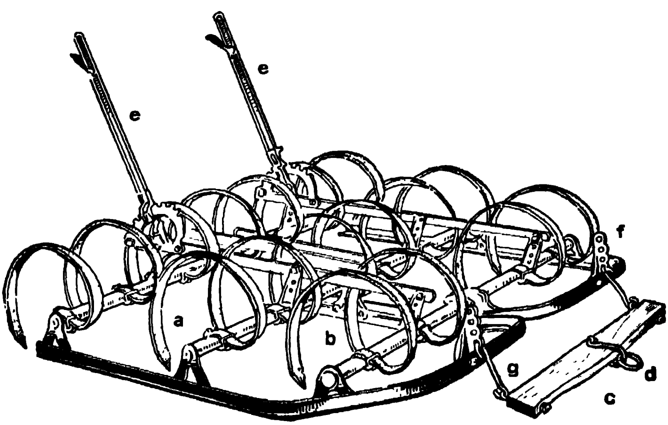
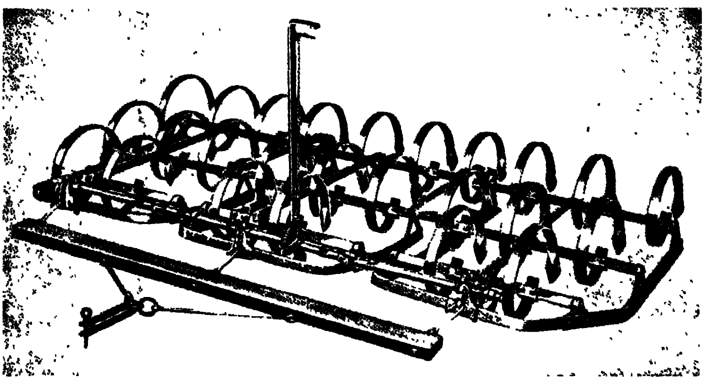


FIG. 59.—Two-section spike-tooth harrow.

6. Levers (Fig. 59, *e*).—The levers provide for setting the depth to which the teeth penetrate. Horse-drawn harrows

have one lever for each section. This is quite common for tractor harrows also although some are made so that with one lever all sections may be adjusted. Figure 60 shows a tractor



Courtesy of Roderick Lean Co.

Fig. 60.—Four-section spring tooth tractor harrow.

harrow of this type. The movement of the levers causes the tooth bars to turn in the tooth-bar standards. The levers are connected to the tooth bars by the rocker bars (Fig. 61, *a*) and the rocker arms (*b*). The levers and lever ratchets (*c*) are connected to the frame.

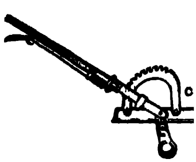


Fig. 61.—Lever connections.

7. Clevis (Fig. 59, *f*).—Several holes are usually provided so that the point of hitch may be raised or lowered, as required, to secure the best results in the field. The clevis is riveted or bolted to the frame. Each section has one clevis.

8. Draft Links (Fig. 59, *g*).—The draft links, which connect the eveners to the clevises, are so shaped that they can be

quickly unhooked when desired and yet are secure when the harrow is at work. An eye bolt connects the front end of the draft link to the evener. The connection between each harrow section and the evener may also be seen at *a* in Fig. 62.

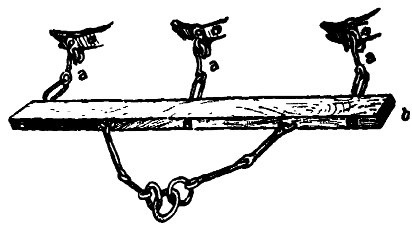


FIG. 62.—Draw rods and hitch ring with 3-section evener.

9. Eveners (Fig. 59, *c*; Fig. 62, *b*). — The evener, by which the draft is distributed evenly to all the sections, is made of wood. Various lengths and combinations of eveners are furnished, according to the number of sections used. At *b* in Fig. 62 is shown a set of eveners for a three-section harrow.

10. Draw Rods and Hitch Ring (Fig. 62).—On two-section

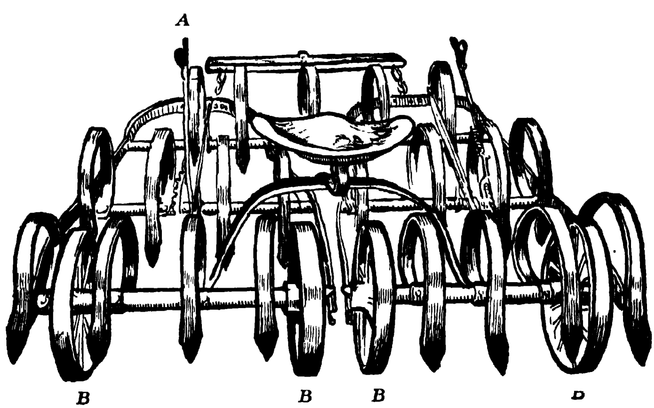


FIG. 63.—Spring tooth harrow with wheels.

harrows the hitch is made by means of a clevis and ring, as shown at *d* in Fig. 59. Where more sections are used, draw rods and a hitch ring are necessary. By this means the power

is attached to the evener at two points, thus causing the sections to pull evenly. The point of hitch (where power is attached) must be such that it will cause the sections to draw evenly and not allow the harrow to skew (one end to lag behind the other). On the two-section harrow it will be noted that the point of hitch falls directly ahead of the center of the two sections. On a three-section harrow the draw rods are attached to the evener in two places, as shown in Fig. 62.

11. Wheels (Fig. 63 *B*).—Wheels are furnished with spring-tooth harrows, if desired. The front wheels are attached to the center of the section frame. Wheels of the castor type are used in order that the harrow may turn more easily. The back wheels are mounted at the corners of the section on the rear tooth bar. A bushing is provided between the tooth bar and the wheel, and the wheel bears on this bushing instead of on the tooth bar. Provision is made for lubrication of this bearing. Horse-drawn harrows that are equipped with wheels can also be furnished with a seat so that the operator may ride.

Job No. 7.

TO OVERHAUL AND REPAIR A SPRING-TOOTH HARROW

Operations Necessary to Perform the Job.

1. Sharpen and adjust teeth.
2. Repair and tighten tooth clamps.
3. Tighten or replace all bolts or rivets connecting through frame. Straighten any bent frame bars.
4. Straighten tooth bars.
5. Repair or replace bearing of tooth bar in tooth-bar standards.
6. Repair levers and lever detents.
7. Straighten rocker bars (if necessary) and secure them to rocker arms.
8. Replace clevises (if required).
9. Repair or replace draft links.
10. Repair all evener parts.
11. Tighten all evener bolts.
12. Paint all parts.

Description of Operations.

Note.—Spring-tooth harrows are used principally on hard and stony ground. They penetrate deeply and do excellent work under severe conditions. It is well for the operator to keep this in mind and to give them proper care and attention.

1. The teeth should be kept sharp in order that the harrow may penetrate hard soil. The points may be ground on the back side. The cutting edge, or bevel, should be ground to an abrupt, tapered edge. A thin edge will not have the strength necessary to stand the severe usage to which the implement is subjected. The operator should notice the manner in which the teeth are ground when new, and should grind the worn teeth in the same manner. This is an excellent rule to follow in sharpening any edged tool. Grinding consists in restoring the edge, as nearly as possible, to its original shape.

All the teeth should be adjusted to the same depth. To do

this, place the harrow on level ground or on a floor. Pull the lever back until the teeth touch the ground. Then examine all the teeth. If any do not touch they may be set deeper by adjustment at the tooth clamp.

2. Examine all the tooth clamps to see if any are loose or broken. Tighten them securely and replace any broken ones.

3. The frame is subjected to heavy strain. All other parts of the harrow are connected to it or are carried by it. Examine the frame bars of every section to see if any are bent or twisted. Tighten all bolts or rivets that connect the draft hooks, runner shoes, and tooth-bar standards to the frame. If the bolts and rivets in such connections remain loose the holes through the frame become enlarged, making it difficult to secure a tight connection. In this case larger bolts or rivets should be used, the hole being drilled out a little larger, if necessary, to make the use of larger bolts or rivets possible.

4. Examine all the tooth bars carefully, to see if any are bent. Bent tooth bars will throw the teeth out of adjustment. They should be removed and straightened. This may be done by hammering them on the anvil. It is not necessary to heat them.

5. The tooth-bar standards provide a bearing in which the ends of the tooth bars turn, when moved by means of the adjusting lever. On some harrows this bearing may be renewed when worn. In others it may be necessary to put in a new standard if there is much wear at this point. The tooth bars must be well secured in the standard, and this point should be examined.

6. Examine the levers and ratchets (Fig. 61, *c*). The detent, which engages in the teeth of the lever ratchet, should be oiled when the harrow is stored away, to prevent rusting.

7. Straighten the rocker bars if any are bent. Tighten the connections between the rocker arms and the rocker bars.

8. Tighten the bolts or rivets connecting the clevises to the frame. Inspect the holes in the clevises for wear, and replace them if necessary.

9. Inspect the draft links for wear and replace them if necessary. Tighten the eye bolts attaching the draft links to

the evener bar. These eye bolts should fill the hole in the evener. If this hole is enlarged, a larger eye bolt should be used. If the proper size bolt is used and it is kept tight, the wear at this point will be greatly reduced.

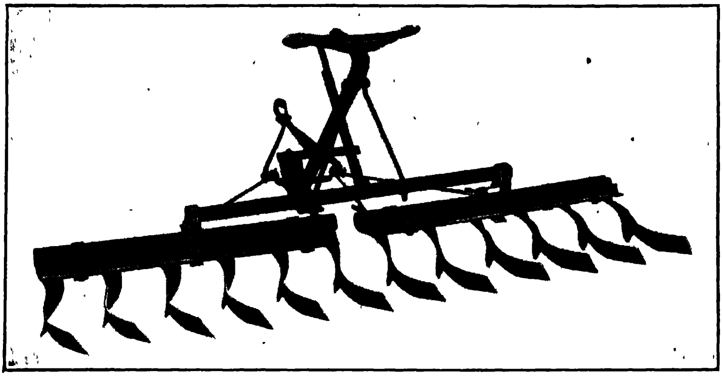
10. Inspect the eveners for cracks or splits. Eveners should be painted and stored away.

11. Inspect the eye bolts that connect the draw rods to the evener. Tighten or replace them in the same manner as the draft-link eye bolts.

12. Paint all parts of the harrow.

SPECIAL TYPES OF HARROWS

A curved-knife or coulter harrow is shown in Fig. 64. This harrow is also constructed in sections and can be procured in widths ranging from about 3 ft. to 28 ft. The former size is a

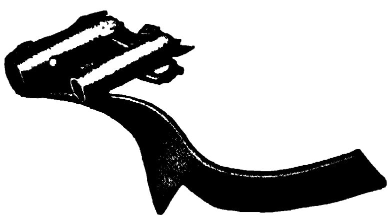


Courtesy of Nash Acme Harrow Co.

FIG. 64.—Curved-knife or coulter harrow.

one-section harrow and is suitable for use with one horse. The larger size is designed for tractor use.

The knives or coulters are spaced about 6 ins. apart. The forward or flat part of the coulter or knife compacts the soil and crushes clods. The central part of the coulter has a narrow fin, extending downward, which causes deeper penetration. The bend or twist of the coulter blade works the soil both right and left (Fig. 65).



Courtesy of Nash Acme Harrow Co.

FIG. 65.—Detail of coulter and crushing spur.

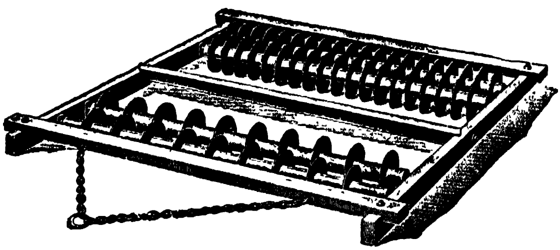
Between each coulter and the adjoining one is placed a

short, flat bar called the crushing spur. These bars aid in compacting the soil and crushing clods.

Extra weight may be carried on the seat braces when deep penetration is required.

This type of harrow leaves a finely pulverized and well-compacted seed bed, when used under suitable conditions.

Figure 66 shows a type of smoothing harrow well adapted to the preparation of the seed bed for garden or truck crops, or where a very fine and smooth seed bed is required.



Courtesy of C. O. Jelliff Mfg. Corp.

FIG. 66.—Special type of smoothing harrow.

Four rows of small disks (8 or 10 ins. in diameter), so placed that no one disk trails another, are used in this type of harrow. This distribution gives the soil a thorough working.

The center board is set at an angle. It is adjustable up or down and acts as a leveler, filling in the hollows and cutting down the ridges in the field.

This harrow may be secured in sizes suitable for one, two, three, or four horses. The width of the largest size is $8\frac{1}{2}$ ft. It is also designed for use with a tractor.

SELECTION OF PROPER TYPE OF HARROW

The various types of harrows and the conditions for which each type is suited were thoroughly discussed at the outset of this chapter. Field conditions and the nature of the work will determine which type should be used, as each is distinctly

adapted to certain conditions. Most extensive farming operations require the use of more than one type of harrow.

The spike-tooth is the lightest in draft, and the disk is the heaviest. Leveling and smoothing are satisfactorily accomplished with the spike-tooth harrow. Hard, stony ground is advantageously worked with the spring-tooth harrow. The disk harrow is particularly serviceable on soddy or trashy ground, as the sharp, rolling disks can be set to cut well through the surface trash and penetrate deeply.

Job No. 8.

TO LUBRICATE ALL PARTS OF A DISK HARROW

Note.—The disk harrow is perhaps the most difficult of all farm implements to lubricate properly. Its bearings work in the dirt and grit whenever it is in operation.

Operations Necessary to Perform the Job.

1. Locate all disk bearings.
2. Force grease into disk bearings until it is squeezed out at side of bearing.
3. Grease axles of tongue truck.
4. Oil lever detents and slides for angling bars.

Description of Operations.

1. Count the number of bearings on the disk gangs. Is each bearing provided with a grease cup?

2. Remove all the grease-cup caps and fill them with grease. Fill the cup (from which cap was removed) also with grease. Screw the caps on to the grease cups and turn them down as far as possible. Remove the caps and refill them. Turn them down again. Repeat this until grease is squeezed out from the sides of the bearing. This is the only sure indication that the bearing is well lubricated.

3. Remove the grease cups (or hub caps) from the tongue trucks. Fill them with grease and turn them down as many times as necessary until the wheel bearings are thoroughly lubricated.

Caution.—The operator must be very careful, when screwing down grease-cup caps, to see that the threads do not become crossed. The caps should turn down easily. If they turn with difficulty it indicates crossed threads. Grease cups are often made of brass and the threads are easily stripped.

4. Oil the lever latches and slides for angling bars, with oil can.

High-pressure Lubrication Systems.

The problem of lubricating farm machines has been simplified by the use of high-compression grease guns. With this equipment it is easier to force grease into bearings. The use of such a system requires that the machines be equipped with special fittings such as those shown in the accompanying illustrations. Many farm machines are now provided with this high-pressure lubricating equipment.

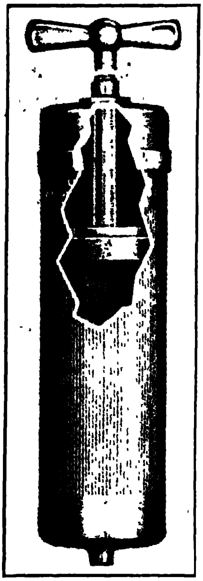


FIG. 67.—Alemite compressor.

The following description and illustrations of a standard system are reproduced through the courtesy of the Bassick Manufacturing Co., Chicago, makers of "Alemite" products.

"Figure 67 is a cutaway drawing of the C-800 compressor. This compressor consists of a cylinder fitted with a piston or plunger, a removable head, and a coupling. The cylinder acts as a container for the lubricant and as a runway for the piston. The piston assembly consists of a disk-shaped cup of leather held in place by two metal disks. The piston is forced up and down in the cylinder by means of a screw, threaded to the cylinder head, and may be easily operated by hand.

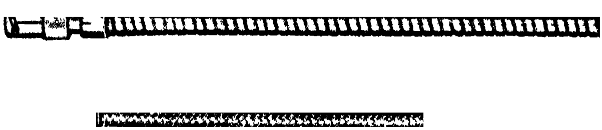


FIG. 68.—Two types of conduit hose for alemite compressor.

"This type of compressor is designed for use with conduit hose, two examples of which are shown in Fig. 68. One end of

the 15-in. hose is screwed into the compressor, and the other is fitted with a bayonet coupling. These hose are steel-covered and built for heavy work. They make possible the lubrication of a bearing with ease, for the hose is flexible and eliminates the use of the compressor at an awkward angle."

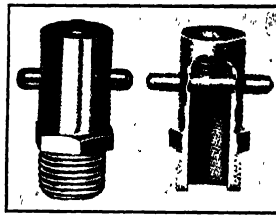


FIG. 69.—Straight fittings.

Figures 69 and 70 show typical Alemite fittings. One end of the fitting is open and is threaded to fit the threads in the bearing, into which an oiler or grease cup has been screwed. The other end of the fitting is the one to which the compressor or hose is to be attached. In order to keep all dirt out of the bearing and to prevent leakage of lubricant, each fitting is sealed by a ball check valve (Fig. 69). The cross pin (Fig. 69) serves two purposes. First, it holds the small check-valve spring in place; and second, its pro-

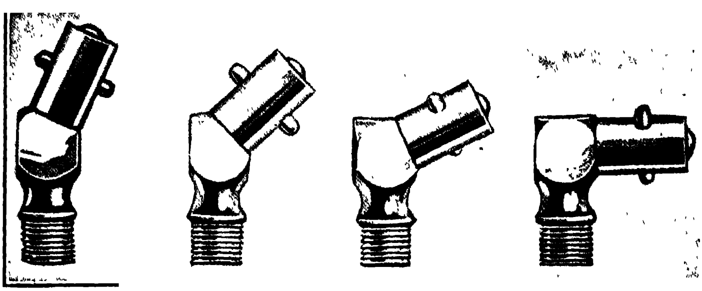


FIG. 70.—Elbow fittings.

truding ends serve as a means of coupling an Alemite hose or compressor.

The fitting, of course, is a gateway or entrance point through which lubricant is forced into the bearing. Each bearing must be equipped with a fitting at the point where the lubricant can best be distributed to all points of the bearing surface. The

fittings remain permanently in their respective places and are never removed.

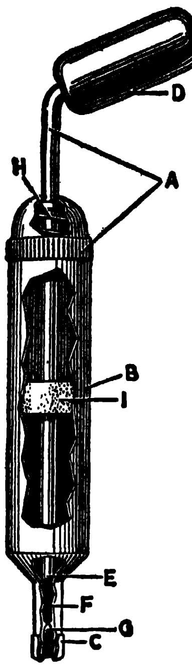


FIG. 71.—Alemite-Zerk compressor.

Figure 71 shows a cutaway view of the Alemite-Zerk 7-C compressor. The action of this is somewhat different from that of the standard Alemite compressor shown in Fig. 67.

"When the compressor is pressed against the fitting, the plunger (*E*) moves forwards, forcing the lubricant in the nozzle tube (*F*) directly through the fitting into the bearing.

"When the pressure on the handle (*D*) is released, the ball check (*G*) in the nozzle (*C*) returns to its seat by the action of

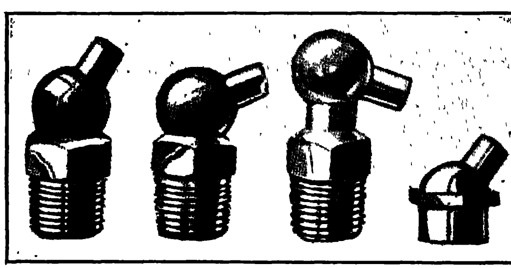


FIG. 72.—Elbow fittings for Alemite-Zerk compressor.

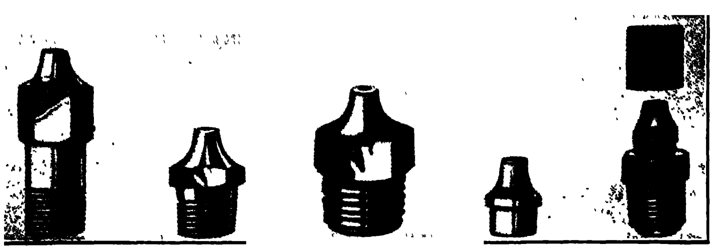


FIG. 73.—Straight fittings for Alemite-Zerk compressor.

the spring (*H*) in the cap (*A*). As the plunger (*E*) is forced back the nozzle tube (*F*) is refilled with new lubricant by vacuum suction and atmospheric pressure against the cork follower (*I*), which slides freely along the plunger stem, causing it to follow the lubricant after each stroke."

Figures 72 and 73 show several types of elbow and straight fittings for the Alemite-Zerk compressor.

JOB NO. 9

TO OPERATE A HARROW

(Spike-tooth, spring-tooth, or disk harrow)

Operations Necessary to Perform the Job.

Note.—Disk harrow should first be lubricated as described in Job No. 8.

1. Transport harrow to one corner of field.
2. Adjust hitch.
3. Adjust depth of harrowing on first trip across field.
4. Lay out field for harrowing (see *a* and *b* in instruction 4 below).

Description of Operations.

1. Transport the harrow to the field with the disks or teeth in the idle (not in the working) position, to prevent tearing up the roadway. Drive to one corner of the field.

2. The problem of hitching with a harrow is not difficult. The center of power can be brought directly ahead of the center of resistance (see Chapter I, page 54). No side draft will exist if all the sections of the harrow are set at an equal depth.

The vertical adjustment of the hitch should be such that the front of the harrow sections penetrates properly. If the hitch is too high at the power unit, or too low at the harrow, the front of the sections may be raised from the ground, or, with a disk harrow, good penetration cannot be secured.

The same condition may result if the hitch rods or chains connecting the harrow to the power unit are too short.

The hitch for a disk harrow should be adjusted so that the stub pole is level when the harrow is in operation. This may be regulated at the tractor draw bar, or, if horses are used, at the tongue truck of the harrow. Proper penetration and light draft cannot be secured without a correct hitch.

3. The depth to which the harrow penetrates is the most

important field adjustment. It is often necessary to change this adjustment in different parts of the same field. The levers are placed within easy reach of the operator, for this purpose.

Spike-tooth harrows can be made to level the ground well and to fill up the dead furrows left by the plow. Proper preparation of a field usually requires that it be harrowed first in the direction in which it was plowed, and then crosswise (called cross-harrowing). In cross-harrowing, much of the dead furrow is filled by the soil dragged into it by the harrow.

In trashy fields it is frequently necessary to raise each section and free it from trash. If allowed to accumulate, the trash will raise the section from the ground.

It is usually not difficult to get good penetration with a disk harrow. On hard ground, sod land, or wet fields, the following adjustments, all of which affect the penetration of the disks, must be carefully checked.

(a) *Scrapers.*—On tractor harrows the scrapers should be set about 1 in. from the outer edge of the disk, and so that the scraper blade just clears the face of the disk when the harrow is in action. On horse-drawn harrows, the foot lever should be adjusted so that the scraper may be moved freely from the center of the disk toward the outer edge, with the lever stop set so as to prevent the scraper from passing beyond the outer edge of the disk.

(b) *Angling Levers.* The angling levers will set the disks at any desired angle. The greater the angle the more deeply the harrow will penetrate.

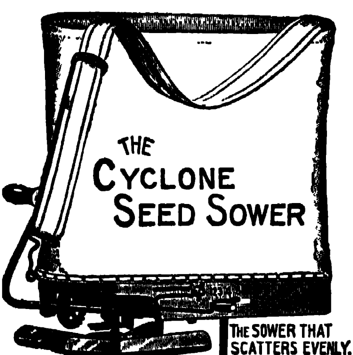
(c) *Third Lever or Snubbing Block.*—A third lever or snubbing block is usually provided, by means of which a downward pressure may be put on the set lever bars. This should be set so that the inner ends of the disk gangs will cut as deep, but not deeper, than the outer ends of the gangs. If too much downward pressure is used the ground will be ridged at the center of the harrow.

CHAPTER III

GRAIN DRILLS

Grain drills are the most satisfactory implements for planting grain. They regulate accurately the amount of seed per acre, plant at a uniform depth, and cover the seed well.

In some regions where the fields are small, the seed is broadcast by hand over the surface of the ground. Machines are also used for broadcasting the seed. These seeders are furnished in many sizes, varying from the knapsack hand seeder (Fig. 74) and the wheel-



Courtesy of R Herschel Mfg. Co

FIG. 74.—Knapsack hand seeder.

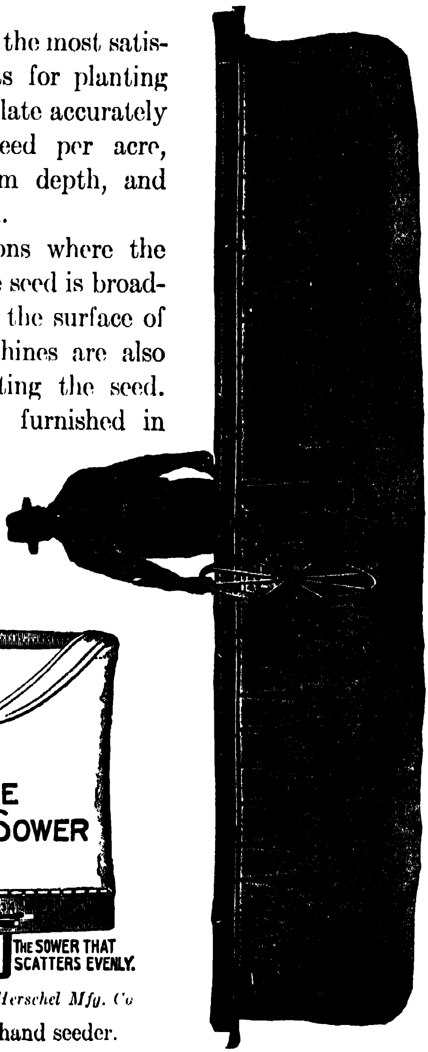
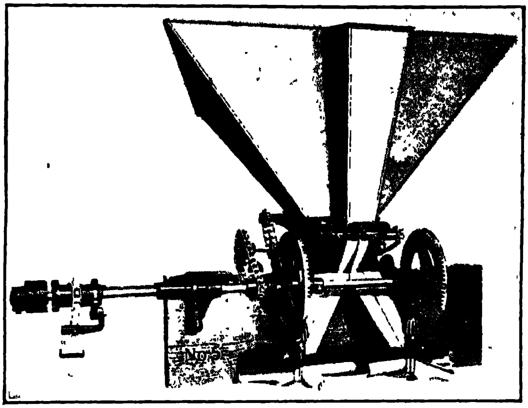

Courtesy of R. Herschel Mfg. Co.

FIG. 75.—Wheelbarrow seeder.

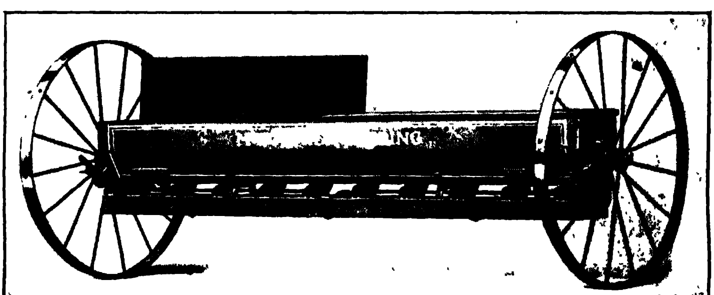
barrow seeder (Fig. 75) to machines large enough to require three or four horses to draw them. The end-gate seeder (Fig.



Courtesy of International Harvester Co.

FIG. 76.—End-gate seeder.

76) is a common type of broadcast seeder. It is designed to be attached to the end gate of a wagon and is driven by



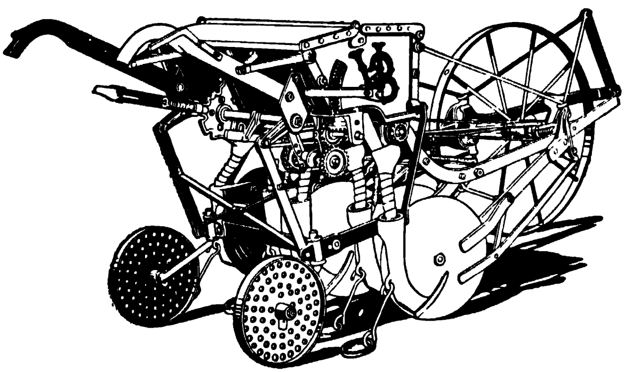
Courtesy of International Harvester Co.

FIG. 77.—A standard type of broadcast seeder.

sprockets and chain, the power being taken from one of the wagon wheels.

Broadcast seeders are also made in large sizes and are in general use in some regions. Figure 77 shows a standard type of broadcast seeder.

Grain drills are used more extensively than seeders. The drill is equipped with furrow openers, so that the seeds are conducted through tubes to the bottom of a small furrow and then covered by means of an appropriate covering device. The drill plants the crop in regular, evenly spaced rows.



Courtesy of Deere & Co.

FIG. 78.—One-horse grain drill with fertilizer attachment.

The grain drill must accomplish the following:

1. Plant the seed evenly (without bunching) at a uniform depth.
2. Sow the proper amount of seed per acre.
3. Maintain equally spaced rows of seed.
4. Cover the seed well.

It is also necessary that a drill be so constructed that it can sow accurately either large seeds, such as peas, or small seeds, such as flax. The quantity of seed desired per acre also varies greatly. Fifteen to 20 lbs. per acre of flax is commonly used, but as much as 90 lbs. of oats is often sowed per acre. The drill must be provided with the proper adjustments to make these changes possible.

The custom of drilling fertilizers in with the seed has become common in many sections. For this purpose the seed box of the drill is made in two compartments, one for the seed and the other for the fertilizer. Drills designed for this purpose are called "fertilizer drills." The term "plain drill" refers to drills that do not drill in fertilizer with the seed.

Sizes.—The size of a grain drill is determined by the number of seed tubes or furrow openers used. One of the most popular sizes has twenty furrow openers, spaced 6 ins. apart. This drill would cover 10 ft. of ground with each trip over the field. The size of this drill is expressed as 20 x 6. Seven-inch and 8-in. spacing of the furrow openers is also used.

Drills may be obtained with as many as twenty-four furrow openers, which makes the drill 12 ft. in width. The smallest size commonly used with two horses is about 5 ft. in width and is equipped with ten furrow openers. Figure 78 shows a one-horse drill.

CONSTRUCTION AND PRINCIPAL PARTS

1. Frame (Fig. 79).—The frame is usually constructed of angle steel. Figure 79 shows a closed-end type of drill frame. The frame should be well braced and strong, as it must hold all parts in proper alignment. It is the base of the drill and all other parts are connected to it. Figure 79, *a*, shows the reinforcement of the corners. The cross ties (Fig. 79, *b*), serve to stiffen and strengthen the frame.

2. Axles.—There are two types of drill axles. One of these is the one-piece or continuous axle, which runs the full length of the frame. The other type is a two-piece or stub axle. The axles are attached to the under side of the frame. Drill axles are "live axles," that is, they turn with the wheels. Suitable bearings are provided for the axles at several points along the drill frame. Power is taken from the revolving axle to drive the feeding mechanism of the drill.

The outer ends of the axle are usually provided with roller

bearings (Fig. 80). As most of the weight of the drill is carried on these bearings, they should be of ample size and should always be kept well lubricated.

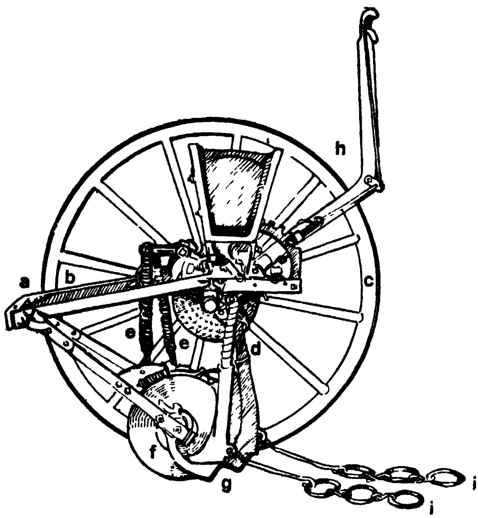


FIG. 79.—Cross section showing construction of the grain drill.

3. Wheels, Ratchets and Pawls.—The wheels (Fig. 79, *c*) may be made of wood or of steel. They are provided with a wide tire (3 or 4 ins.) to prevent their sinking deeply into the soft seed bed.

Where the long, one-piece a x l e is used the wheels are connected to it by means of ratchets and pawls. The pawls (Fig. 81, *c*) are held by rivets to the hub cap (*d*). The hub cap is fastened securely to the axle by a pin, which passes through the hole in the hub cap. The inside of the hub of the wheel is built with a series of notches or teeth which engage the pawls. These are so shaped that when the wheels turn forward the pawls and hub cap revolve with them. The hub cap, being securely pinned, causes the axle to turn with it. Thus the forward motion of the wheels not only transports the machine but also is the source of power for driving the seeding and fertilizer-feeding mechanisms.

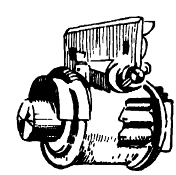


FIG. 80. — Roller bearing used on grain-drill Axle.

The reverse motion of the wheels, when the drill is backed up, causes the notches in the wheels to slip over the pawls with-

out engaging them. Thus, when the drill is backed up, the axle does not turn and the feeding mechanisms do not operate. When the drill is turned around, the wheel on the outside of the turn drives the axle, while the one on the inside slips over the pawls. The action on a turn is similar to that of a differential.

This construction is referred to as "ratchet drive" or "ratchet and pawls." It is used on many farm machines and should be clearly understood by the student. The construction is simple and gives little trouble when the parts are new and properly fitted to each other. As the machine is used and the parts wear, the ratchet is likely to slip over the pawls. The pawls and pawl springs (Fig. 81, *a*) must be renewed frequently. Sometimes the pawls come loose while the machine is in operation, usually because the hub cap, which carries the pawls, is not tight against the wheel that carries the ratchet or teeth. There is usually an adjustment provided to keep these parts snugly together. In some drills, two or more holes are drilled through the hub cap (Fig. 81, *d*). If the pin is put through the outer hole the two parts are drawn tighter together.

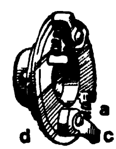


FIG. 81.—Hub cap, pawls and pawl springs.

Where two-piece or stub axles are used, the ratchet and pawls are not necessary, the wheel being pinned directly to the axle. Each wheel and axle is independent of the other, and each drives one-half of the feeding mechanism of the drill. These mechanisms are built in halves.

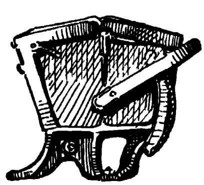


FIG. 82.—End view of seed and fertilizer hoppers.

4. Seed Box, or Hopper.—The seed and fertilizer hoppers are carried on top of the frame. The sides are made of wood and the ends of the box are of iron. Figure 82 shows an end-view of the hoppers on a fertilizer drill. They are placed toward the rear of the frame. The front compartment carries the seed and the rear compartment the fertilizer.

The interior construction of the seed hopper is illustrated in Fig. 83. The metal bridges (*a*) deliver all the grain to the feed cups (*b*). These bridges prevent the accumulation of unseeded grain at the bottom of the box.

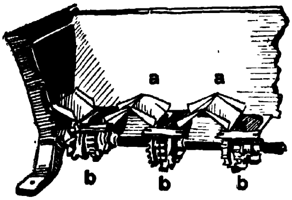


FIG. 83.—Interior view of one type of seed hopper.

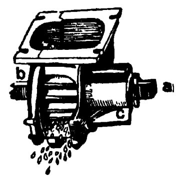


FIG. 84.—Fluted grain-feeding device.

Truss rods are used on large drills to reinforce the box and prevent its sagging in the middle.

5. Grain-feeding Devices (Figs. 84 and 87).—There are two principal types of grain-feeding devices used on drills.

(*a*) *Fluted Force Feed.*—Figure 84 shows a fluted force-feed cup. One of these cups is provided for each furrow opener. They are attached to the bottom of the seed box (Fig. 83, *b*). The fluted feed wheel revolves with the square feed shaft (Fig. 84, *a*). The recesses in this wheel are filled up with grain, which is delivered as indicated in Fig. 84.

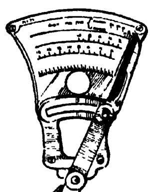


FIG. 85.—One type of feed-regulating lever used with fluted feed.

The deflector lip (Fig. 84, *b*) cleans the wheel and prevents the grain from being carried back into the seed cup.

The cut-off, or follower (Fig. 84, *c*), enters the feed cup through slots cut in one side. Its function is to shut off a portion of the feed cup so that the amount of grain to be sowed per acre may be regulated. The fluted wheel and the follower may be moved together in or out of the feed cup by means of the feed-regulating levers (Figs. 85 and 86). The position of the adjustable

gate at the bottom of the feed cup may be changed as required for the various sizes of seeds to be planted. In some drills this gate may be entirely opened for sowing large seeds, such as peas or corn, or for convenience when cleaning out the seed box of the drill.

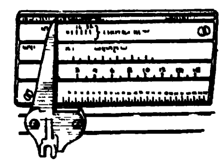


FIG. 86.—Another type of feed-regulating lever used with fluted feed.

(*b*) *Double-run Force Feed.*—This type of feed cup is illustrated at *C* in Fig. 87. Both sides of the wheel (*C*) are ribbed or fluted. One side has small recesses and is used for sowing small grains. The other side of the wheel has larger spaces and is used for sowing the larger seeds, such as oats or beans. One wheel is provided for each furrow opener. The entrance to

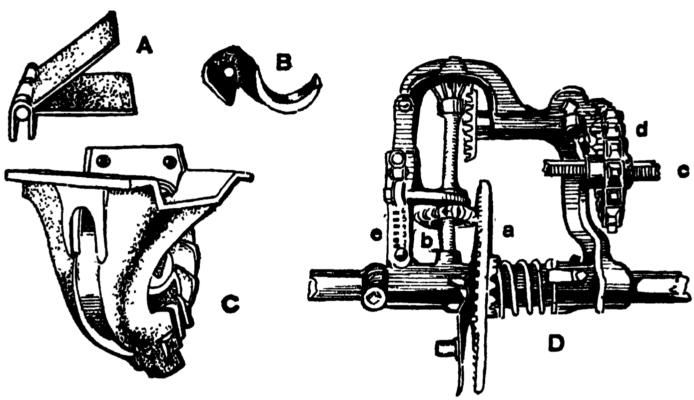


FIG. 87.—Double-run type of grain-feeding device.

the side not in use is closed by means of a hinged metal lid in the bottom of the seed hopper (Fig. 87, *A*).

The entire surface of the grooves in the feed wheel is always in contact with the grain, in this type of feed. The rate of seeding is controlled by varying the speed of the shaft which drives the ribbed feed wheels. A study of Fig. 87, *D*, will show how this is accomplished. A large multiple gear, with several

rows of teeth (*a*), is carried on the axle. Setting the sliding gear (*b*) toward the center of the large multiple gear will transmit a comparatively slow motion through the gears and chain to the square feed shaft (*c*). This causes the ribbed feed wheels to turn slowly, with the result that the amount of seed per acre is small.

If the sliding gear (*b*) is set at the outer edge of the multiple gear, the rate of seeding is increased. There are usually from six to ten different settings possible on the multiplė gear.

Reducers (Fig. 87, *B*) are often used in feed cups to cut down the rate of seeding. These are metal pieces which are pressed into the bottoms of the seed cups. They decrease the size of the opening so as to give better control of the seeding rate of small grains. The reducers are removed with a small wire hook, when not in use.

6. Seed Tubes.—The seed tubes (Fig. 88, *a*) are commonly made of ribbon steel. They are fitted at the upper end with a metal cup which is attached to, and encloses, the feed cups at the bottom of the hopper. This metal cup may have three tubes or branches leading into it, as shown at *b*. One branch is for the seed, one for the fertilizer, and one for the grass-seed attachment. (Grass seed is often planted with the drill. The grass-seed attachment is discussed on page 123).

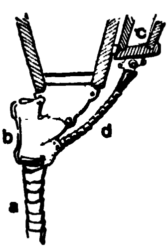


Fig. 88.—Seed tubes and seed cup.

The metal seed cup (*b*) for plain drills has only two branches, one for the seed and the other for the grass seed. The seed tubes are sprung over the bottom of the feed cups and are held in place by a flat spring latch. The entire seed tube can be easily removed without the use of tools.

The function of the seed tube is to conduct the seed and fertilizer from the hopper down to the furrow opener. It should provide a straight and smooth passage for the seed, and should enclose and protect it from the scattering effect of the

wind. Figure 88, *a*, illustrates clearly the position of the seed tubes.

7. Furrow Openers (Fig. 89).—There are four types of furrow openers commonly used on drills. They all have the same function, namely, to open a furrow of the desired depth, into the bottom of which the seed is dropped.

(*a*) *Hoe Furrow Opener* (*C*).—This is the oldest type in use. It is furnished with a double-pointed shovel (*b*). If this shovel is kept sharp, good penetration may be secured. One objection to the hoe furrow opener is that it tends to become clogged up in a trashy field. It is the simplest and perhaps the most durable of all types.

Spring trips are usually provided, so that the hoes are automatically released if an obstruction is encountered. Hoes with wooden break pins (such as are used on cultivators) may also be secured.

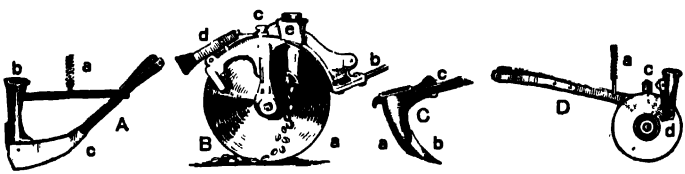


FIG. 89.—Four types of furrow openers.

The penetration is increased by means of a pressure spring. The amount of downward pressure exerted by this spring is controlled by the lifting levers (Fig. 79, *h*).

All types of furrow openers are provided with pressure springs, but the point at which the pressure is applied varies on the different types.

Hoe furrow openers may be assembled in a straight rank, or they may be in "zigzag" rank like the single-disk furrow openers shown at *d* in Fig. 79. The zigzag placement is best for trashy fields as it gives more clearance between the hoes. The angle of the furrow opener is adjustable by means of the three holes shown at *c* in Fig. 89, *C*.

The hoe furrow opener is the most satisfactory type for use on rough, stony ground.

(*b*) *Shoe Furrow Opener* (*A*).—This furrow opener is usually assembled on the drill in zigzag rank. The blades are made of high-carbon steel and may be resharpened on the anvil when dull. They scour well, and if properly adjusted will not give trouble in trashy fields. The draft of the drill is much reduced by the use of shoe furrow openers.

An adjustment is provided for raising or lowering the forward end of the shoe. This adjustment is useful in preventing the nose of the shoe from picking up trash.

The pressure spring is attached at the point indicated at *a*. The pressure is regulated by the setting of the lifting lever (Fig. 79, *h*).

The lower end of the seed tube enters into the boot (*b*), which conducts the seed directly to the bottom of the furrow.

(*c*) *Single-disk Furrow Openers* (*D*).—The disks are arranged in zigzag rank as illustrated at *d* in Fig. 79. One-half of the disks throw the soil toward the right, and the other half toward the left side of the drill, in the same manner as in the disk harrow.

The seed boot is placed on the convex side of the disk. It should reach well down toward the bottom of the disk so that the seed will be deposited in the very bottom of the furrow.

The pressure spring is attached as indicated at *a*. The pressure is regulated by the setting of the lifting lever. The tension of the pressure spring is also adjustable in many makes of drills. One method of adjusting this is by means of a wire hook at the bottom of the spring. By moving this hook to a higher hole the spring is raised and compressed. Thus the pressure on the furrow opener is increased. Pressure springs may be made in two pieces, so that one part threads around the coils of the other. The pressure is increased by turning the coil up, and decreased by turning it down.

As the disks revolve when the drill is in operation, they must be provided with a bearing, which must be well designed, carefully made, and properly lubricated. Since this bearing is so

located that it operates continually in a cloud of dust and grit, it should be dust-proof and oil-tight. Figure 90 shows the construction of the bearing of a single-disk furrow opener. The two bearing surfaces (*b* and *c*) are made of chilled iron. One of these surfaces *c* is riveted to the disk and revolves with it. The other *b* is stationary and is bolted to the drag bar *f*. A dust washer *a* and a ring *e* are used to make the bearing dust-proof. The dust ring is held in place with a coil spring *d*.

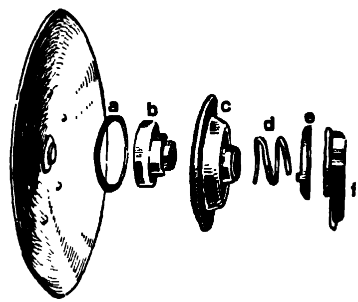


FIG. 90.—One type of bearing used in single-disk furrow openers.

The bearings may be lubricated with oil or grease. The oil plug is shown at *c* in Fig. 89, *D*.

Both sides of the disks are provided with scrapers. The lower end of the boot is provided with a scraper which cleans the convex side of the disk (Fig. 79, *g*). The scraper for the concave side of the disk is shown at *d* in Fig. 89, *D*. This is also adjustable, and may be set off the disk entirely when not needed. Scrapers are particularly useful in muddy, sticky soils.

The single-disk furrow opener is widely used. It penetrates well and gives the ground an additional cultivation. It cuts through trash easily and is often used for drilling grain into fields of corn stubble that have not been plowed.

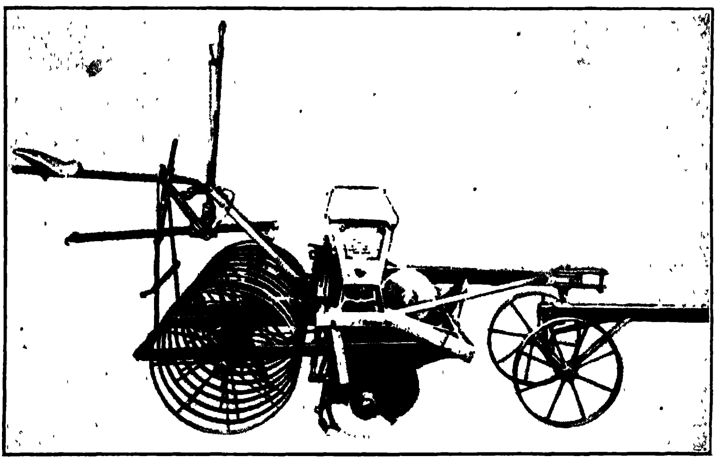
The single-disk furrow opener has more wearing and moving parts than the hoe furrow opener. The action of the single disk throws all the soil to one side so that the drag chains (Fig. 79, *i*) cover the seed almost entirely with soil from one side. Single-disk furrow openers cause heavier draft because of the thorough manner in which they work the soil.

(*d*) *Double-disk Furrow Opener.*—Figure 89, *B*, shows an interior view of a double-disk furrow opener. The location of the drag bar *b*, the oil tube *c*, and the outside scraper *d* are

clearly shown. The grain boot *e*, which conducts the seed to the bottom of the furrow, is located between the two disks.

The two disks are made of flat blades of steel set at an angle to each other. They meet at the front, with one extending slightly ahead of the other. This causes better penetration. The spread at the rear of the disks causes them to open a furrow from $1\frac{1}{2}$ to 2 ins. wide.

Figure 89, *B*, shows an interior view with one disk removed.



Courtesy of Peoria Drill and Seeder Co.

FIG. 91.—Press-wheel drill.

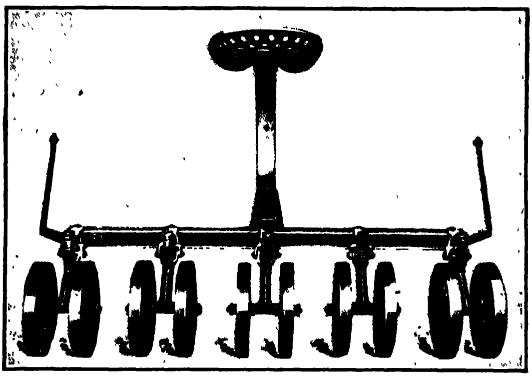
The double-disk does not penetrate as well or cultivate the ground as thoroughly as the single-disk. It covers the seed somewhat more evenly, and the draft is lighter. The inside and outside scrapers prevent clogging on wet or sticky fields. The single-disk opener cuts through trash better than the double-disk.

8. Covering Devices (Fig. 79, *i*).—Drag chains are commonly used for covering the seed. They are hooked into the

rear of the seed boot. One chain is provided for each furrow opener.

Drag chains are used with all the types of furrow openers mentioned above. They cover the seed well but do not pack or firm the soil above it.

In sections where it is desirable to conserve the soil moisture carefully, and in dry seasons, the press-wheel drill is used (Fig. 91). In this drill press wheels replace the high wheels of the standard drill. The feeding mechanisms are driven by a chain from the press wheels.



Courtesy of Peoria Drill and Seeder Co.

FIG. 92.—Press-wheel attachment for standard high-wheel drill.

Press-wheel attachments may be secured for the standard high-wheel drill (Fig. 92).

One press wheel follows each furrow opener and firmly packs the soil above the seed.

9. Fertilizer-feeding Device (Fig. 93).—The most commonly used fertilizer-feeding method is called the "finger feed." The location of the fingers in the bottom of the hopper is shown in Fig. 93. One finger wheel is provided for each furrow opener. The finger wheel is seated into a bevel gear on the bottom of the fertilizer hopper (*b* and *c*). The bevel gear meshes with a

small pinion (*d*) which is connected to the fertilizer feed shaft.

As the fingers revolve in the bottom of the hopper, the space between them fills up with fertilizer. These small loads of fertilizer are carried toward the adjustable gate (*e*), which controls the size of the opening to the fertilizer outlet. The gates are adjusted by means of the lever shown in Fig. 82. A series of notches for this lever makes possible twenty-five or thirty settings of the gates.

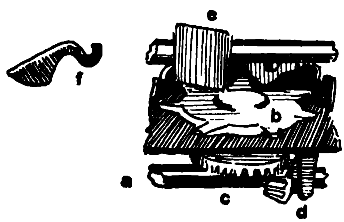


Fig. 93.—Fertilizer feeding device.

A knocker (Fig. 93, *f*), with a heavy head is pivoted just over the outlet to the seed tube. As the fingers pass over this outlet the knocker is raised by the finger and drops on the spaces between the fingers. This breaks up any lumps of fertilizer, drives them through the outlet, and prevents plugging.

The amount of fertilizer required per acre is subject to great variation. Fertilizer feeds, therefore, must have a wide range of adjustment. Many fertilizer drills may be adjusted to sow from 50 to 1100 lbs. of fertilizer per acre. This adjustment is accomplished by the setting of the gates, as above mentioned, and also by varying the speed of the fertilizer feed shaft. The speed of this shaft may be regulated by means of a change of the gears, which provide at least two speeds. The fertilizer feed shaft is driven from the drill axle by a chain.

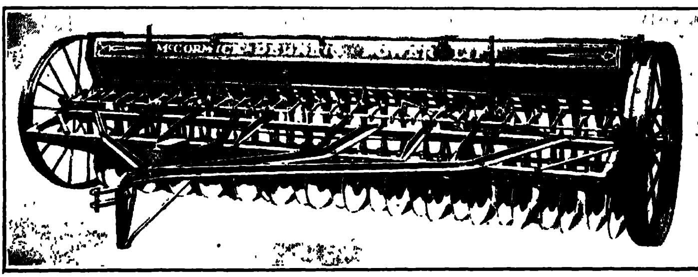
10. Lifting Devices (Fig. 79, *h*).—Two levers, called the lifting levers, are usually provided for raising and lowering the furrow openers. Each lever raises one-half of the furrow openers. Tractor drills are often provided with a power lift. This is operated by a rope from the driver's seat on the tractor and is very similar in construction to that used on plows.

11. Clutch.—A simple type of toothed clutch is placed on each end of the main axle. Lowering the furrow openers engages these clutches, so that the feeding mechanisms begin

to operate as soon as the furrow openers are lowered. In some types of drills it is possible to disengage the clutch when the furrow openers are down. With disk drills this is convenient, as it is frequently desirable to disk without seeding or to seed with only one-half of the drill.

12. Grass-seed Attachments (Fig. 88, *c*).—A small hopper for grass seed may be attached in front of the main hopper. A small tube (Fig. 88, *d*) conducts the grass seed into the main seed tube and plants it with the grain.

The grass-seeding attachment is driven from a sprocket on the main axle. The construction of the hopper and feeding mechanism is very similar to that of the grain drill.



Courtesy of International Harvester Co.

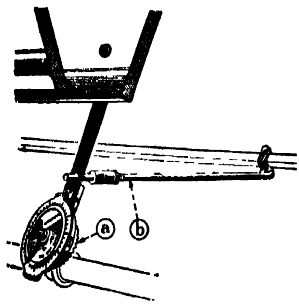
FIG. 94.—Power lift tractor drill.

13. Poles and Tongue Truck.—Small grain drills are usually furnished with one pole. Drills of 8 ft. or more have two poles and are equipped with four-horse eveners. A drill with a tractor hitch is shown in Fig. 94.

Tongue trucks or forecarriages may be secured. They are particularly desirable when drawing several drills behind one tractor.

14. Surveyor, or Land Measure (Fig. 95).—A surveyor, or land measure, is usually placed on the back of the hopper. It is driven from a worm on the main axle, which drives a worm gear on the back of the surveyor (*a*).

The surveyor operates only when the drill is seeding. The movement of the drill axle causes the dials of the surveyor to turn very slowly. A certain number of turns of the drive wheels will move the drill far enough to seed one acre. The same number of turns moves the dial through a certain space, which is marked 1, or 1 acre, on the dial. The dial reads in acres or fractions of an acre. The surveyor is very useful in enabling the operator to keep a careful check on the quantity of seed per acre. A throw-out arm *b* throws the surveyor out of action when the furrow openers are raised.



Courtesy of International Harvester Co.

FIG. 95.—Surveyor or land measure.

LABORATORY STUDY NO. 6

To determine the accuracy of planting or the amount of grain sowed per acre.

Equipment Necessary.—Grain drill and a bushel or more of seed grain.

Procedure.

1. Jack up the drill so that the drive wheels are free from the floor.
2. Place the grain to be sowed in the seed hopper.
3. Determine the number of revolutions of the drive wheel necessary to plant an acre. To do this, the diameter of the drive wheel and the width of the drill must be considered. In making this test, each half of the drill should be tested separately.
4. Set the feed-regulating device to sow the desired quantity.

Example.—Suppose it is desired to sow oats at the rate of 6 pecks per acre.

(*a*) For fluted-wheel feed drills the indicating lever should be set according to the indicator plate on the hopper (Figs. 85 and 86).

(*b*) For internal double-run feed drills the adjustment is made by moving the sliding gear in or out on the multiple gear (Fig. 87, *D*). In this case it might be set by placing the latch, which moves the gear, in notch No. 3 (Fig. 87, *e*) provided that the small sprocket (six-tooth) is used at *d*. Two sprockets are usually furnished for this type of feeding device.

The six-tooth is the slow-speed and the twelve-tooth the fast-speed sprocket.

Complete grain and fertilizer sowing tables are furnished with each drill. In some drills they are printed on sheets of paper or tin, tacked to the inside of the lid of the hopper. In other makes the figures are cast into the metal at the ends of the

hopper. The information contained in these tables is very important and should be carefully preserved.

5. Lower the furrow openers so that the feeding mechanism is in gear.

6. Set the surveyor, or land measure, at zero.

7. Give the drive wheel the required number of turns to plant $\frac{1}{4}$ acre.

8. Measure the amount of grain planted.

(*a*) If too much has been planted, the setting of the feeding mechanism or the adjustment of the seed cups is not right, or parts of the feed cup may be worn, allowing too much grain to pass through.

(*b*) If too little has been planted, the setting may be wrong, or parts of the feed cups or wheels may be plugged up.

9. Take the reading of the surveyor dial (this usually reads in fractions) and compare it with the amount of ground theoretically covered. In this manner a double check may be obtained on the rate of seeding per acre.

LABORATORY STUDY NO. 7

To determine the accuracy (amount per acre) of the fertilizer-feeding device.

Equipment Necessary.—Same as for Laboratory Study No. 6, using fertilizer in the fertilizer hopper instead of seed in the grain hopper.

Procedure.—Same as for Laboratory Study No. 6. Fertilizer-sowing tables are furnished with each drill, or may be secured from the manufacturer's instruction book sent with the drill.

Job No. 10

TO REPAIR A GRAIN DRILL

Operations Necessary to Perform the Job.

1. Clean grain hopper, fertilizer hopper, and feed cups.
2. Test and lubricate feed shafts.
3. Replace worn chains or gears.
4. Replace worn pawls and springs.
5. Adjust stub axles (if used).
6. Adjust pressure springs.
7. Test and adjust furrow-opener parts.
8. Remove disks. Clean and lubricate disk bearings (where disk furrow openers are used).
9. Adjust scrapers.
10. Adjust balance springs.
11. Grease surface of disks to prevent rust.
12. Paint all other metal and wood parts.

Description of Operations.

1. Remove the seed tubes and thoroughly clean out the grain hopper, fertilizer hopper, and all feed cups. Some types of fertilizer are injurious to metal, and the drill should never be stored away with any fertilizer in the hopper.

2. Oil all bearings of the feed shafts and all gears that drive the feed shafts. Jack up the drill, lower the furrow openers, and turn the drive wheel by hand until the feed shafts turn easily and freely. Frequently these parts become rusted.[1] If taken to the field in this condition the shafts are very often broken.

3. Replace any worn chains or gears between the main axle and the feeding mechanism.

4. Remove the wheels from the main axle. Clean and lubricate the main wheel bearings. Examine the pawls (if used) and

[1] If the feed shafts are stuck tight it is best to loosen them by turning them with a monkey wrench, before attempting to turn them with the drive wheel.

replace any that are worn or broken. Test the tension of the pawl springs and replace weak springs.

When replacing the hub caps be sure that the pawls are properly engaged in the ratchet of the wheel and that there is a slight looseness, or end play, between the wheel and the hub cap.

5. With stub axles, adjust the inner end of the axle so that top of the drive wheel slants slightly away from the hopper. This adjustment cannot be made on drills that have the one-piece axle.

6. Examine the pressure springs. Replace any that are broken and adjust all to equal tension.

7. Raise the furrow openers from the floor and test each one for loose connections. The connections may become loose at the drag bar, between the seed boot and the drag bar, or at the frame of the drill. Uneven and ragged seeding results. Tighten all such connections.

8. Remove the disks, clean and lubricate the bearings (where disk furrow openers are used). Test the bearings for looseness and replace any that are worn. A loose bearing causes the disk to wobble, and poor seeding results. Be sure all oil tubes are clean, so that the disk bearings will receive proper lubrication.

9. Adjust the scrapers to conform to the surface of the disks.

10. Adjust the balance springs (attached to lifting lever) so that this spring pressure is sufficient to help raise the furrow openers when the lever arm is " past center " in the upward position and also to help force them down when the lever arm is " past center " in the downward position.

11. Cover the steel surfaces of the furrow openers with a thick coating of grease to prevent rust.

12. Paint all other metal and wooden parts of the drill.

Job No. 11

TO LUBRICATE ALL PARTS OF A GRAIN DRILL

Operations Necessary to Perform the Job.

1. Grease or oil disk bearings.
2. Grease or oil axle bearings.
3. Grease or oil bearings of all other working parts.

Description of Operations.

1. Grease or oil the disk bearings thoroughly. The bearings are dust-proof only when full of grease. Bearings that have become worn through lack of proper lubrication result in poor seeding.
2. Grease or oil the main axle bearings.
3. Oil the bearings of the following parts:

   (*a*) feed shaft;
   (*b*) gears;
   (*c*) surveyor worm and gear;
   (*d*) fertilizer feed shaft;
   (*e*) sprockets;
   (*f*) lever detents;
   (*g*) power-lift parts (tractor drills).

Job No. 12

TO OPERATE A GRAIN DRILL

(Fertilizer Type)

Operations Necessary to Perform the Job.

1. Distribute bags of seed and fertilizer across ends of field.
2. Operate drill idle for a few minutes. Lubricate thoroughly.
3. Adjust hitch.
4. Fill seed and fertilizer hoppers and adjust rate of seeding and flow of fertilizer. Set surveyor.
5. Start seeding at one edge of field (leave headlands at each end if necessary).
6. Regulate depth of seeding.
7. Seed main part of field.
8. Seed in headlands.

Descriptions of Operations.

1. Distribute sacks of grain and fertilizer along the ends of the field so that the hoppers may be conveniently filled as required. The operator should always be sure that the hoppers are sufficiently full to complete the trip across the field. If they become empty in the field it is difficult to find the exact spot where the seeding stopped, and an unseeded place may thus be left.

2. Squirt kerosene on the bearings of all parts of the feed shaft and fertilizer shaft. Turn these shafts slightly with a monkey wrench to make sure they are free. Breakages often occur because the drill is started with these shafts stuck.

Lower the furrow openers and operate the machine idle for a few minutes. Stop and raise the furrow openers and oil all parts of the drill thoroughly, as described in Job No. 11.

3. The horizontal hitch presents no difficult problem with drills. The power unit may be connected to the center of the drill so that the center of power and the center of resistance fall in the same line.

The vertical hitch should be such that the seed and fertilizer hoppers will be level when the drill is in operation. This may be regulated by the neckyoke straps where horses are used, or at the connection between the pole and the frame. On tractor drills the necessary adjustment may be made at the stub tongue or tongue truck (if used) or in some cases on the draw bar of the tractor.

If the pole is too high above the ground, the rear of the drill will be lowered. This results in too deep planting and covering. If the front end of the pole is too low, the seed will not be planted deep enough or will not be thoroughly covered.

4. Fill the seed and fertilizer hoppers. The amount of seed to use per acre depends upon the climate, the fertility of the soil, the amount of rainfall, the size of the seed, and many other factors. It is a problem that should be given ample study, and the results of the various regional customs should be carefully observed.

The amount of fertilizer to be used per acre also depends upon a variety of factors.

The method of setting the rate of seeding and the rate of sowing fertilizer has been thoroughly discussed in this chapter and explained in Laboratory Studies Nos. 6 and 7. The operator is again cautioned to preserve the seeding tables and fertilizer-sowing table furnished with the drill. In some cases these tables are printed on cardboard sheets. These sheets should be kept in a safe place.

The surveyor, or land measure, should be set at zero before each new field is started. This may be done by loosening the nut that holds the dial hand and turning the dial back to zero. This adjustment is important in that it gives the operator a means of checking up on the rate of seeding.

5. Lower the furrow openers and start across the field with the drill seeding just inside the space desired for a headland. Raise the furrow openers when the opposite headland is reached. Turn the drill clear around with furrow openers raised. Lower the furrow openers after the turn is completed and seed back

across the field. On the return trip, have the drill wheel on the inside of the strip lap over the wheel mark made on the first trip across. In this way no ground will be left unseeded.

Headlands, or turning strips, are left at each end of the field, as in plowing. A convenient method is to leave headlands of equal width on all four sides of the field. The work is begun at one corner. The drill is driven straight across the field, seeding as it goes. When the headland at the opposite side is reached, the furrow openers are raised. The drill is turned entirely around on the headland. The furrow openers are lowered again after the turn is complete, and the drill is in position to start the seeding for the return trip across the field.

6. The depth of seeding is regulated by the raising levers and the pressure springs. The setting of the pressure springs will vary for different soils. A setting that would give the proper depth of seeding on hard ground would cause the depth to be too great on soft ground. In very loose soil the weight of the furrow openers alone is often sufficient to give the necessary penetration.

7. Seed in the main body of the field by making successive trips back and forth. Be sure that the inside wheel always laps over the previous wheel mark.

The following adjustments may best be made after seeding has begun:

> (*a*) *Adjustment of Balance Springs.*—The tension of these springs should be set so that the furrow openers are raised properly and are held firmly in the raised position by the springs.
>
> (*b*) *Adjustment of Scrapers* (disk furrow openers).—The tension of disk scrapers should be sufficient to clean the disks properly when the soil is wet. In dry weather the scrapers are not necessary, and should be turned back away from the disk.

8. After the main part of the field has been seeded by trips back and forth across it, the headlands may be seeded. To

accomplish this the drill is driven clear around the field, the furrow openers being kept in the lowered position during the entire trip. When finishing up a field it is often desirable to seed with only one half of the drill. The last unseeded strip may be so narrow that only half the drill is required to seed it. The opposite half of the furrow openers may be raised (and thus not seed) or they may be kept in the lowered position and the clutch controlling the feed shafts disengaged.

FIELD TROUBLES

1. Trashy Fields.—On trashy fields the furrow openers become plugged up and raised from the ground with the result that the seed is scattered. A single-disk drill is the most satisfactory for such conditions.

2. Worn Disk Bearings.—This condition allows the disks to wobble. The rows become irregular, and some of the seed is scattered and not covered properly.

3. Lack of Penetration.—This trouble may occur on very hard ground even though all parts of the drill are in good condition. It is usually due to improper setting of the raising levers or pressure springs.

4. Seed Cracked by the Drill.—A wrong adjustment of the feed cup causes this trouble. All modern drills are capable of the necessary adjustments to plant nearly all seeds.

5. Rate of Seeding too Fast.—This is a common trouble caused by a wrong setting of the feed. Oftentimes operators forget to put in the reducers (Fig. 90, *B*) and the rate of seeding is too fast even though the setting is correct.

6. Rate of Seeding too Slow.—This is caused by an improper setting of the feed-changing device, or by the use of reducers when they are not required.

Drilling is a more satisfactory method of planting grain than broadcasting. Less seed is necessary, the seed is covered more evenly, and germination and growth are more nearly uniform.

Grain drills are used much more extensively in the grain-producing regions than are broadcast seeders. The results of many experiments indicate that the yield is better with drilled seed than with broadcast seed.

Grain drills are designed for operation either with horses or with tractors. Power-lift devices, for raising the furrow openers from the ground, are usually supplied on tractor drills. Stub or short poles are also used on tractor drills. When several drills are pulled behind one large tractor, they must be hitched so that there will be no unplanted ground between the strip seeded by one drill and that seeded by the following one.

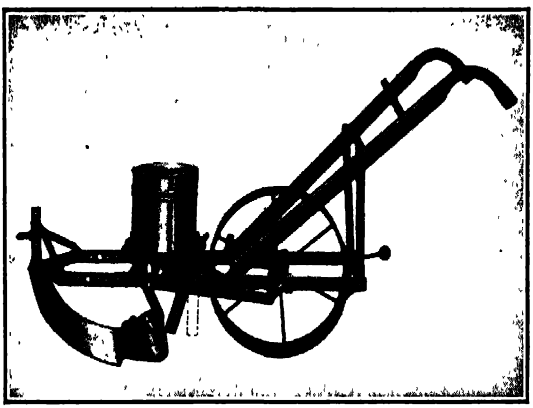
CHAPTER IV

CORN PLANTERS

Corn planters may be divided into three classes, as follows:

1. Drills.
2. Listers.
3. Check-row planters.

The drill and the lister plant the kernels at regular intervals along the row. This method of planting is called "drilling." Another method is to plant the corn in hills, with several kernels

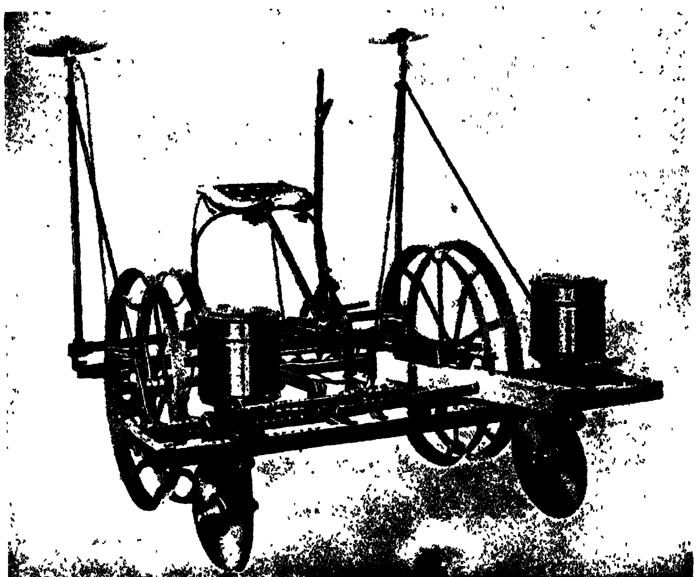


Courtesy of American Seeding Machine Co.

Fig. 96.—One-horse corn drill.

in each hill. Most corn planted in hills is put in with a check-row planter. The use of the check-row planter makes it possible to have the hills line up both ways. For this reason a field planted with a check-row planter may be cultivated in two

directions (cross-cultivated). It is possible to secure a hill-drop device for some makes of corn drills and corn listers. Such a device will plant corn in hills, but the hills do not "check" or line up both ways. Cross cultivation would be impossible with this type of planting. The check-row planter, however,



Courtesy of American Seeding Machine Co.

FIG. 97.—Two-horse, two-row corn drill.

can be used for either drilling or check-row planting. It accomplishes either style of planting equally well.

Corn Drills (Figs. 96 and 97).—The corn drill is the simplest of the three types. Figure 96 shows a one-horse corn drill. A steel runner, or shoe, is used to open the furrow for the seed. The kernels drop from the hopper through the metal seed tube to the bottom of the open furrow. The corn is covered by the main wheel, which tracks behind the seed tube.

This wheel also drives the seed plate, which revolves inside of the hopper. The driving power is transmitted from the wheel to the seed plate by means of the pitman, shown in Fig. 96.

A two-horse, riding corn drill is shown in Fig. 97. This machine plants two rows at a time. The width between the rows may be varied from about 30 ins. to 48 ins. The construction is similar to that of the one-row corn drill. A chain from the main axle turns a drive shaft which extends from one hopper to the other. Both seed plates are driven by this shaft. Each main wheel tracks behind a furrow opener and covers the seed.

Both the single-row drill and the two-row drill may be equipped with fertilizer attachments, so that the fertilizer may be distributed when the corn is planted.

Corn drills are usually furnished with three sets of seed plates (Fig. 98). One set may have twelve seed cells, one nine, and the other six. When the twelve-cell plate is used, the kernels are planted close together or about 7 ins. apart. With the nine-cell plate the interval is 10 ins., and with the six-cell plate about 15 ins.

Courtesy of Am. Seeding Machine Co.

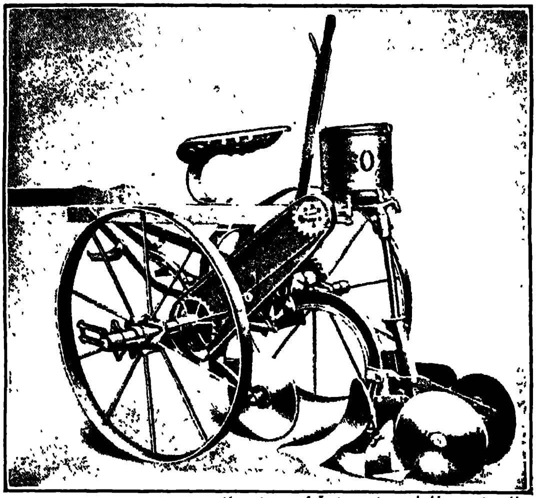
FIG. 98.—Seed plate used in corn drills.

The interval between kernels may also be changed by varying the speed of the seed plates in relation to the main wheel. This is accomplished by a change in the gears, sprockets or pitmans used to drive the seed plates. Provision is made for making this change easily.

Special seed plates may be secured for planting many other kinds of seed. Beans or peas may be planted with this type of drill, or may be planted with the corn if desired.

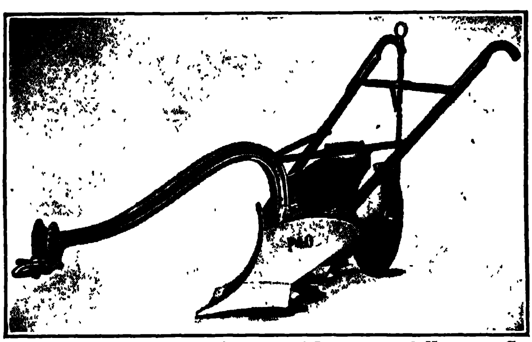
Corn Listers.—A two-horse, riding corn lister is shown in Fig. 99, and a walking lister in Fig. 100. The moldboard of

the lister throws the soil both ways, thus leaving an open furrow or trench for the seed. It might be said that the lister has a



Courtesy of International Harvester Co.

FIG. 99.—Two-horse riding corn lister.



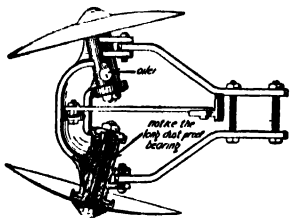
Courtesy of International Harvester Co.

FIG. 100.—Two-horse, walking corn lister.

double moldboard. The construction and placement of the principal parts are clearly shown in Figs. 99 and 100. The

seed is dropped from the hopper through the seed tube to the bottom of the open furrow. Two disks (Fig. 101) follow the seed tube and cover the seed.

A vertical steel blade will be noticed just to the rear of the moldboard in Fig. 99. This acts as a rudder and prevents the lister from swinging to one side in case the pressure on the two moldboards should be unequal.



Courtesy of International Harvester Co.

FIG. 101.—Covering disks used on corn lister.

A small subsoil knife or plow will be noted just ahead of the disks in Fig. 99. This penetrates and loosens the subsoil just ahead of the seed tube.

The distance between kernels may be varied on the lister in the same manner as on the corn drill. Cotton or beans and many other seeds may be planted with the lister by using special hoppers and plates.

The chief advantages of the lister planter are as follows:

1. Saving of time and labor.—The seed bed is prepared and the seed planted in one operation.

2. Saving of moisture.—The seed is planted at the bottom of the trench, so that the plants root deeply and use more of the subsoil moisture.

3. Prevention of soil blowing.—The ridges left by the lister reduce this very effectively.

Check-row Corn Planters.—The check-row corn planter is more widely used than either of the other types, for the reasons stated on page 137. It is the type commonly used in the Corn Belt. As the principles of its construction embody those used in the other types, it will be described here in detail.

This machine may be used to plant the corn in hills or to drill it in rows. It is often referred to as a check-row planter. By the use of wire, the hills are planted at equal distances apart in each direction. The distance between hills in the same row is the same as the distance between rows. Corn planted in

hills by means of the check wire may be cultivated in two directions, or cross-cultivated. This is advantageous in keeping the fields free from weeds.

The corn planter must be capable of adjustments, making it possible to vary the number of kernels planted in the hill. If it is used for drilling the corn, the distance between kernels must be controlled by adjustments provided on the planter. The distance between hills is determined by the distance between the buttons on the check-row wire (Fig. 111).

The corn planter must open a furrow of proper depth for the seed, drop the seed to the bottom of the furrow at the proper rate or interval, and cover the seed in the furrow. In addition to this, the rows must be straight and at equal distances from each other.

CONSTRUCTION AND PRINCIPAL PARTS

1. Wheels.—The open-tire wheel (Fig. 102, *a*) is the most popular type. Closed-tire wheels and double wheels are also used.

One of the wheels is retained on the axle by means of two collars, one inside and one outside of the wheel. These are adjustable so that the wheel may be lined up with the furrow opener.

The other wheel drives the axle and is bolted to it. Several holes are provided in the axle for the bolt so that the spacing of this wheel may also be regulated.

2. Main Frame (Fig. 102, *b*).—The main frame is usually made of a single piece of flat or channel steel which is bent into the shape shown. The holes in the front of the main-frame bars provide for attaching the main frame to the runner frame (Fig. 102, *c*). Axle boxes are bolted to the main frame and carry the axle beneath it (Fig. 102, *d*).

3. Axle (Fig. 102, *e*).—The axle is usually a hollow-steel tube from 1 to $1\frac{5}{16}$ ins. in diameter and about 50 ins. in length. The series of holes at one end provide for the proper spacing of the

drive wheel, in order to make it follow directly behind the furrow opener.

Double or triple sprockets (Fig. 102, *f*) are carried on the main axle. A chain runs forward from these to the feed shaft of the planter. Sprockets of various sizes are used to change the rate of seeding as required. A sprocket for winding up the

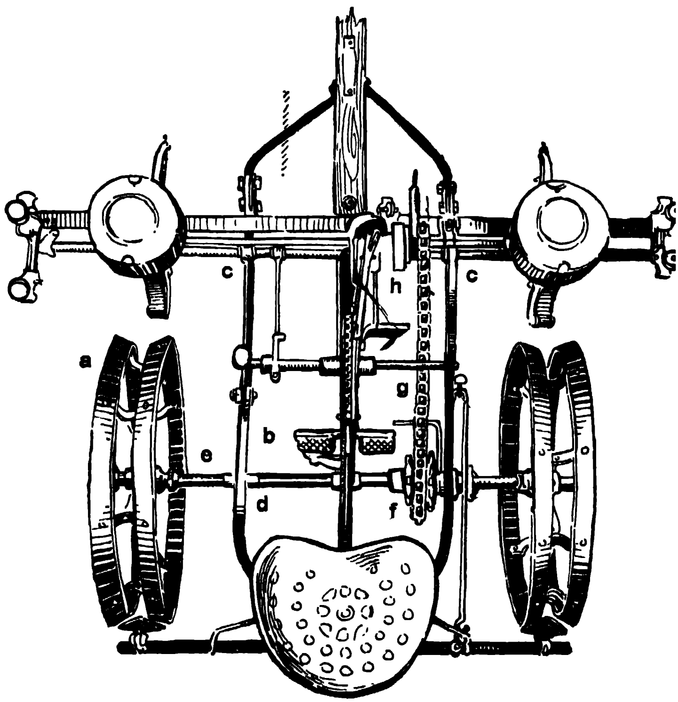


FIG. 102.—Principal parts of the check-row corn planter.

check wire and one for driving the fertilizer attachment are also carried on the rear axle. A clutch is usually placed on the rear axle to operate and control the sprocket which drives the fertilizer attachment.

4. Furrow-opener Frame or Runner Frame.—The front ends of the main frame are bolted to the runner frame as shown

in Fig. 102, *c*. The runner frame extends across the planter and supports the seed hoppers and the seed-dropping plates. The runner frame is made of one or two long bars of flat or I-beam steel. Square pipe bars are also used. The ends of some runner frames are closed so as to form a narrow rectangle. The corners are usually reinforced, and braces are placed across the frame in several places. The furrow openers, or runners, are connected below the runner frame.

Accuracy and uniformity of planting depend to a large extent upon the rigidity of the runner frame, as the parts that actually touch and control the flow of seed are mounted on the runner frame.

5. Feed Shaft (Fig. 102, *h*).—The feed shaft is mounted on top of the runner frame and is driven by a chain from the rear axle (Fig. 102, *g*). The proper method of placing the chain on the sprocket is illustrated in Fig. 103. Note that the hooks are placed forward with the slots out. The speed of the feed shaft may be changed by using the various driving sprockets on the rear axle (Fig. 102, *f*). Changing the speed of the feed shaft is one method by which the distance between kernels in drilled rows may be varied.

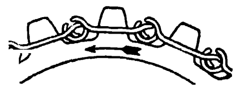


Fig. 103.—Proper method of assembling chain on driving sprocket.

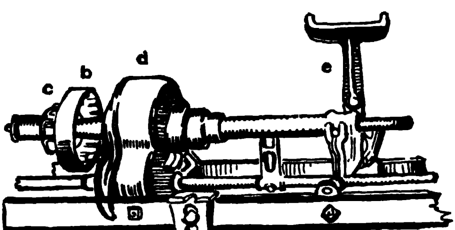


Fig. 104.—Clutch and one type of variable drop mechanism.

6. Seed Boxes, or Hoppers (Figs. 106 and 107).—The seed boxes, or hoppers, are mounted on the runner frame directly above the furrow openers. One seed hopper is provided for each furrow opener. They are fastened in place with a latch and a pivoted connection so that they may be easily inverted. It

is necessary to invert the seed hoppers when emptying out unused seed, or when changing the seed plate.

7. Clutch (Fig. 104).—The clutch is mounted on the feed shaft; it transmits the driving power from the feed-shaft sprocket (Fig. 104, *c*) to the feed shaft. The sprocket is not keyed to the feed shaft but runs freely on it. The clutch must be engaged before the feed shaft is driven by the sprocket.

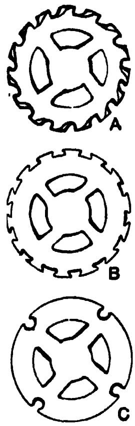


FIG. 105.—Three types of seed plates.

When drilling corn the clutch is always engaged and the feed shaft turns steadily. When check-rowing corn the clutch is engaged before each hill is planted and disengaged after it is planted. The feed shaft, consequently, turns intermittently when check-rowing. The engaging and disengaging of the clutch is accomplished automatically, at exact intervals, by means of the buttons on the check-row wire (Fig. 114, *a*).

8. Seed Plates (Fig. 105).—The seed plate is located in the bottom of the hopper, as shown in Fig. 98. There are three types of seed plates used in corn planters. The edge-drop, as the name signifies, carries the kernel of corn on edge in the revolving seed plate, as shown in Fig. 106. The edge-drop plate is illustrated in Fig. 105, *A*: The flat-drop carries the kernel flat in the cell of the plate (Fig. 105, *B*). Both the edge-drop and the flat-drop seed plates accumulate the necessary number of kernels for a hill one at a time. Each seed cell carries one kernel. As this cell passes over the outlet to the seed boot (Fig. 107, *c*) the kernel drops down to the first valve (Fig. 107, *b*). When the desired number of kernels have been collected, the

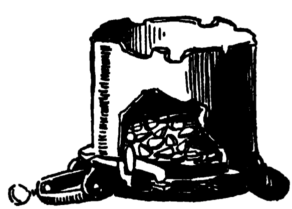


FIG. 106.—Interior view of hopper and seed plate.

valve is opened and they are dropped to the lower valve (Fig. 107, *e*) and thence to the bottom of the seed furrow.

The full-hill-drop plate (Fig. 105, *C*) has large holes at equal intervals around the edge of the plate. These are large enough to allow several kernels (enough for one hill) to drop through to the valve. For this reason the plate is called full-hill-drop. This type is not used as generally as the other two, as it does not plant as accurately.

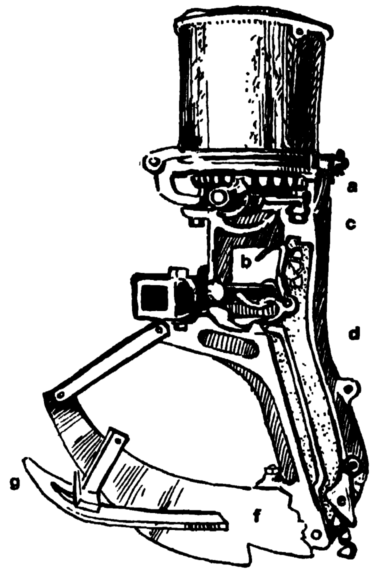


FIG. 107.—Interior view of seed boot and valves.

Most corn planters are so designed that any one of the three types of seed plates may be used with them. The edge-drop seems to be the most satisfactory, provided the seed used is graded.

The cells that carry the seeds are located around the outer edge of the seed plate. The bottom of the seed hopper is crowned, or raised, so that all the corn is delivered to the cells of the plate.

As the seed plates revolve, each cell passes over the outlet (Fig. 107, *c*) and drops its kernel. The cut-off, shown in Fig. 106, prevents two kernels from entering the same seed cell and also prevents kernels from lodging or sticking in the cell.

Several sets of plates are furnished with each planter. These are usually marked large, medium, and small. This refers to the size of the cells, and the proper plates should be used for the size of the kernels to be planted.

9. Seed-plate Gear and Pinion (Fig. 107).—The seed-plate gear is located directly beneath the seed plate. Notches on the upper side of this gear engage with and drive the seed plate. A small pinion meshes into the under side of the seed-plate gear and transmits the drive to it. The pinion is pinned to the feed shaft. Several holes are drilled through the feed shaft so that the position of the pinion may be changed when the width between the furrow openers is varied.

10. Variable-drop Devices (Fig. 104, *d*).—When planting corn in check rows it is desirable to be able to change quickly the number of kernels in the hills. In some parts of the field four kernels per hill may be desirable, while in other parts two kernels or three may be preferred. Check-row planters are usually fitted with a device for accomplishing this change.

Four methods are in common use:

(*a*) The pinion on the end of the feed shaft may be provided with three sets of teeth. This may be shifted to cause the seed plates to travel so that two, three, or four kernels may be planted in each hill.

(*b*) The seed-plate gear may carry three rows of teeth on the under side. Shifting the pinion into the various rows of teeth accomplishes the change in the number of kernels in much the same manner as described above.

(*c*) Another type of variable-drop controls the distance, or rather the part of a complete revolution, made by the feed shaft for each hill planted. To plant four kernels, the feed shaft makes a complete revolution and four seed cells pass the outlet to the seed boot. To plant three kernels, the feed shaft makes but three-quarters of a revolution; and to plant two kernels, only one-half a revolution.

(*d*) Three gear changes may be provided for the various speeds of the feed shaft. These are carried in an oil-tight case (Fig. 104, *d*) and are operated by the shifting lever (Fig. 104, *e*). The principle on which they act is similar to that used for tractor or automobile transmissions.

In all the foregoing types of variable-drops, the movement

of the feed shaft, and consequently the movement of the seed plates, is controlled by the clutch. The feed shaft will turn only when the clutch is engaged. The means by which it is engaged and disengaged for the planting of each hill will be explained later in this chapter.

11. Seed Boot (Fig. 107, *d*).—The seed boot forms a passageway for the seed from the seed plate down to the bottom of the furrow. It is usually in the form of a large rectangular tube of cast iron. The furrow opener is attached to the lower end of the seed boot.

12. Valves (Fig. 107).—Two valves are enclosed within the seed boot. One of these is located directly below the seed plate (Fig. 107, *b*). The other is located near the bottom of the seed boot, close behind the furrow opener (Fig. 107, *e*).

When planting corn in hills, the valves are closed until the required number of kernels are accumulated. Then the valves are opened by the action of the buttons on the check wire. The kernels carried above the lower valve drop to the bottom of the furrow. The kernels that were carried above the upper valve drop down through the seed boot and are caught by the lower valve. Springs return the valves to the closed position. Valve action is so rapid that when the kernels are released from the upper valve the lower valve is closed in time to catch them. The action of the valves and the passage of the kernels of corn through the seed boot are illustrated in Fig. 107.

The location of the lower valve makes it possible to carry the seed for one hill low down, near the bottom of the furrow. When the valve opens, these kernels are dropped together; they all reach the ground at the same time and are not scattered along at intervals. If only one upper valve were used it would be impossible to get three kernels planted near enough together to form a good hill.

When drilling corn, the valves are not in use. They are locked in the open position with a latch or small foot lever, conveniently placed near the operator's seat. The clutch is in constant engagement, and the seed plates revolve steadily (not

intermittently, as for hill planting). Each kernel drops from its cell in the seed plate, through the outlet, down through the seed boot to the bottom of the furrow.

13. Checking Head (Fig. 108)—The checking fork (Fig. 108, *b*) applies the action of the buttons on the check wire to the planter. In order that the student may fully understand this somewhat puzzling action, a complete explanation will be given.

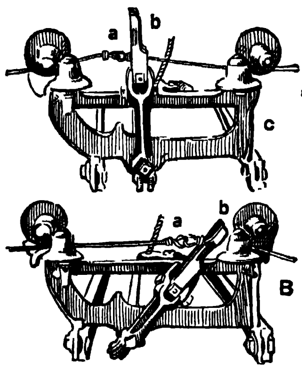


Fig. 108.—Checking head.

(*a*) The check-row wire (Fig. 114) reaches clear across the field. It is staked securely beyond each end of the field by means of two anchor stakes (Fig. 114, *a* and *b*).

(*b*) The wire is entered through the checking head (Fig. 108). The checking head includes all of the parts of the planter that guide or control the wire. Roller guides are used to hold the wire in the checking head and guide it to the checking fork.

(*c*) As the planter is driven across the fields, the wire slides through the checking fork. One button after another strikes the checking fork and bends it down, as shown in Fig. 108, *B*.

(*d*) The action of the checking fork opens the valves and engages the clutch. When the button on the wire has bent down the checking fork to the extreme position shown in Fig. 108, *B*, the button slips past and the checking fork returns to its original upright position. The return of the checking fork allows the valves to close and the clutch to disengage.

When the button on the wire strikes the checking fork and bends it backward, the following events take place simultaneously:

1. Kernels above the lower valve drop to the ground.
2. Kernels above the upper valve drop to the lower valve.
3. The clutch engages, causing the seed plates to turn and

accumulate the kernels for another hill, above the upper valve.

When drilling corn, the checking wire is not used. The checking fork is held down, the valves are always open, the clutch is constantly engaged, and the seed plates turn steadily.

14. Furrow Openers.—The furrow openers are attached to the lower end of the seed boot. Their function is to open a furrow of uniform depth into which the seed may be dropped. The depth of the furrow and the depth of planting are regulated by means of the lever shown in Fig. 97. A compression spring is used in connection with this lever to secure good penetration of the furrow openers.

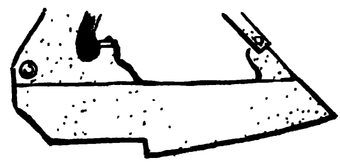


Fig. 109.—Stub-runner furrow open.

There are four types of furrow openers in common use. Figure 107, *f*, shows the curved-runner opener; Fig. 109, the stub-runner; and Fig. 110, the single-disk. Double-disk furrow openers are also commonly used.

The description of disk furrow openers in the chapter on drills applies equally well to those used on the corn planter. The construction of the curved-runner or shoe furrow opener is also similar to that of the shoe furrow opener used on drills.

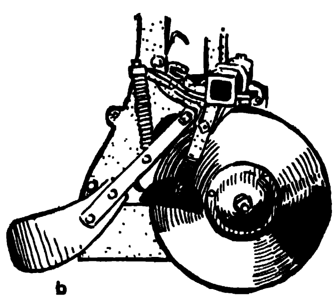


Fig. 110.—Single-disk furrow opener.

The stub-runner opener is designed for use on ground that has a great many stones or a large amount of trash. The stub-shaped front of the runner gets under such obstructions and pushes them aside.

Gauge shoes (Fig. 107, *g*) are frequently used with the furrow

openers. They serve to maintain a uniform depth in loose or very mellow soils.

15. Covering Devices (Fig. 110, *b*).—A set of coverers is usually furnished with the planter, but in many soils their use is not necessary. The main wheels of the planter have a tendency to gather the soil and tamp or pack it lightly over the seed.

16. Fertilizer Attachment (Fig. 111).—Fertilizer attachments may be mounted on any of the modern corn planters.

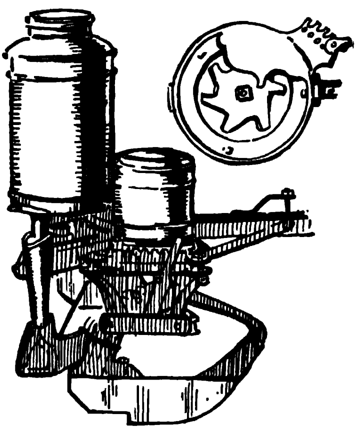


FIG. 111.—Fertilizer attachment with interior view of finger feed.

A sprocket on the main axle drives the feed shaft of the fertilizer attachment. The speed of the feed shaft may be varied by changing the sprockets, thus varying the rate of flow of the fertilizer. The amount of fertilizer distributed may also be changed by an adjustable gate provided on each hopper.

The fertilizer feed is of the finger type (Fig. 111). The action of the finger feed is described in the chapter on drills.

A fertilizer tube leads from the bottom of the hopper down to the rear of the furrow opener. A valve, placed in the lower end of this tube, is operated by the check fork, in unison with the valves of the seed boot. The action of this valve drops the fertilizer in the soil in the proper position with relation to the hill of corn.

When drilling corn, the fertilizer valve is locked in the open position, in the same manner as the valves in the seed boot. This results in the fertilizer's being drilled steadily into the row.

17. Markers (Fig. 112).—It is very desirable that corn be planted in straight rows, as such rows are easily and thor-

oughly cultivated and result in better yields. To obtain straight rows it is necessary that the planter be drawn in a straight line across the field. The function of the marker is to make a distinct line or mark in the soil which will serve as a guide to the operator. Figure 114 shows the position of the marker when the planter is in operation. The operator keeps the pole of the planter directly over the line made by the marker on the previous trip across the field. Two types of markers are shown in Fig. 112. These are both adjustable to suit the width between the furrow openers. The adjustment of the marker must be changed if the distance between the furrow openers is varied. The horizontal distance from the center of the planter to the line made by the marker should always be twice the distance between the furrow openers.

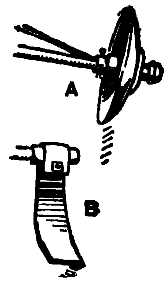


FIG. 112.—Two types of markers.

At each end of the field, when the planter is turned around for the return trip, it is necessary to swing the marker from one side of the planter to the other, in order that the mark may be made in the unplanted side of the field. A means for reversing the marker is usually provided. In some planters, however, double markers are used so that reversing the marker is not necessary.

18. Check-row Wire and Reel (Fig. 113).—A section of check-row wire with the buttons is shown in Fig. 114. Wire is usually furnished with the planter in 80-rod lengths. More or less must be used according to the length of the field. Special connecting links are placed every few rods, so that the wire may be disconnected easily and the desired length obtained.

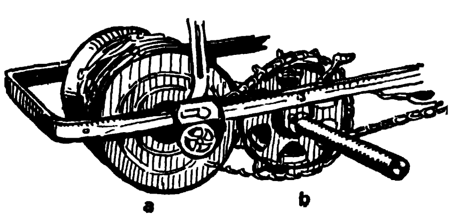


FIG. 113.—Reel for check check-row wire.

The spacing of the buttons on the wire determines the distance between the hills in the row. Wire suitable for any desired distance of planting, from 30 to 48 ins., may be obtained.

The wire, when not in use, is carried on the wire reel (Fig. 113, *a*), which is made large enough to carry 160 rods. The reel is also used for unwinding and winding up the wire. It is driven by a sprocket on the axle, as shown in Fig. 113, *b*, or by means of a frictional contact with the main wheel. A tension-regulating device is provided so that the wire may be kept tight, and a guide is used to distribute the wire evenly over the reel.

Job No. 13

TO TEST A CHECK-ROW CORN PLANTER FOR ACCURACY OF PLANTING; TO SET PLANTER FOR DRILLING

Operations Necessary to Perform the Job.

1. Jack up planter.
2. Fill hoppers with seed.
3. Make test for accuracy of planting:
   - (*a*) With "small" seed plates in hopper, at rate of three kernels per hill.
   - (*b*) With "small" seed plates in hopper at rate of two kernels per hill.
   - (*c*) With "small" seed plates in hopper at rate of four kernels per hill.
   - (*d*) Make the above three tests (*a*, *b* and *c*) with "large" plates in hoppers.
   - (*e*) Make the above three tests (*a*, *b* and *c*) with "medium" plates in hopper.

4. Adjust planter as required to change from check-row planting to drilling.

Description of Operations.

1. Jack up the planter securely, so that both wheels and also the furrow openers are off the floor. Have the runner frame level.

2. Fill each hopper about half full of seed corn.

3. Put the "small" seed plates in place under the hopper.

4. Set the variable-drop lever to drop three kernels per hill.

5. Set the foot-trip lever so that the valves in the seed boot are closed.

6. Revolve the driving wheel of the planter at about the same speed at which it would turn in the field.

7. While the wheel is revolving steadily, have another student trip the check fork. (It should be tripped quickly and allowed to return promptly to the closed position.)

8. Make fifteen or twenty drops in this manner, and count the number of kernels dropped each time.

9. Set the variable-drop lever for two kernels per hill and make the same test.

10. Set the variable-drop lever for four kernels per hill and make the same test.

11. Make the same tests with the "large" seed plates, and then with the medium seed plates, in place in the seed hopper. Which set of plates gives the most accurate planting?

12. Determine the adjustments necessary to change from check row planting to drilling.

13. Adjust the planter for drilling. Determine how the drilling distances may be varied.

Job No. 14

TO REPAIR A TWO-ROW CORN PLANTER

Operations Necessary to Perform the Job.

1. Remove, clean, and oil all chains.
2. Examine feed-shaft bearings.
3. Clean and repair clutch.
4. Clean and repair variable-drop mechanism.
5. Clean out fertilizer and seed hoppers.
6. Loosen and lubricate valves.
7. Replace worn or broken parts of checking heads.
8. Inspect furrow openers.
9. Tighten bolts and rivets.

Description of Operations.

1. Remove all chains and soak them in a pail of kerosene, then in oil. The kerosene loosens and removes the dirt and hardened grease, and the oil prevents rusting.

2. Revolve the feed shaft and examine the bearings. Replace them if necessary. Loose or worn bearings may cause the pinion on the feed shaft to slip out of mesh with the seed-plate gear. This would cause irregular planting.

3. Examine the clutch and replace any weak springs or worn parts.

4. Clean all parts of the variable-drop mechanism with kerosene. Examine the parts carefully and test the action of each part. Replace worn parts. Lubricate all moving parts of this mechanism thoroughly.

5. Clean out the seed hoppers, remove the seed plates, and wash off any accumulation of dirt on the seed-plate driving parts. See that the seed-plate gear and feed-shaft pinion mesh properly and are not loose.

6. Clean out the fertilizer hopper. If fertilizer remains in the hopper, the finger-feed wheel will become stuck.

Brush over the feeding parts with an old paint brush dipped in oil. See that the gate, which adjusts the rate of flow, and the fertilizer drive shaft act freely

7. Oil the shafts in the seed boots on which the valves pivot. See that the valves and checking fork act freely. Valves should return to the closed position with a quick snap.

8. Oil all moving parts of the checking head, wire guide rollers, latches for wire release, etc.

9. Examine the bearings of the furrow openers (if they are disk openers). Replace these bearings if necessary. Lubricate well.

10. Tighten all bolts or rivets. Replace chains.

Job No. 15

TO OPERATE A CHECK-ROW CORN PLANTER

Operations Necessary to Perform the Job.

1. Lubricate all parts.
2. Select proper seed plates.
3. Adjust hitch (height of pole).
4. Set planter to give desired width between rows.
5. Stake out check wire and begin planting.
6. Adjust depth of planting.
7. Set variable-drop to plant desired number of kernels per hill.
8. Set rate of flow of fertilizer.
9. Plant main body of field.
10. Plant across headlands.

Description of Operations.

1. Lubricate all parts. The principal parts requiring lubrication are as follows:

(*a*) Main-axle bearings.
(*b*) Feed-shaft bearings.
(*c*) Clutch parts.
(*d*) Variable-drop device.
(*e*) One of the drive wheels (the other is pinned and revolves with the axle).
(*f*) Bearings of disk furrow openers.
(*g*) Bearing of disk-marker.
(*h*) Valves and check forks.
(*i*) Fertilizer feed shaft and clutch.
(*j*) Fertilizer attachment valves.
(*k*) Rollers on checking head.
(*l*) Bearings of reel hangers.

2. Select the proper seed plates. Each planter is furnished with several sets of plates which vary in the size of the seed

cells. They are marked large, medium, and small. These terms refer to the size of the kernels for which the plates are to be used.

To get the best results in planting corn, the seed should be graded. Small machines, called "seed-corn graders" may be obtained for this purpose. The accuracy of the planter is greatly increased by grading the seed. If a seed-corn grader is not available, fairly uniform kernels may be obtained if the seed is taken only from the central portion of the ear. The tip kernels and the butt kernels should be discarded.

When kernels of uniform size are obtained, it is an easy matter to select the seed plate into which they fit the best.

3. Adjust the hitch. The eveners are carried on top of the pole, which is in the center of the corn planter. Consequently, no side draft will exist and the horizontal hitch will present no problem. The adjustment of the height of the pole, however, is important if the corn is to be planted in check rows.

If the front of the pole is carried too low the hills will be dropped a few inches behind the button on the check wire. Raising the pole will throw the furrow openers forward and cause the kernels to be carried a little further before being dropped.

The kernels must be dropped at points almost directly below the buttons on the check wire. If, on the first trip across the field, the kernels for the hill are dropped 3 ins. behind the button, then on the return trip they will also be dropped 3 ins. behind the button; but, as the planter is moving in the opposite direction, this means that the hills of the first two rows will be several inches out of check with those of the next two rows. This will be the case throughout the entire field. The height of the pole should be such that the kernels are dropped not more than $1\frac{1}{2}$ ins. behind the button on the check wire.

To make sure that the rows are in line crosswise, it is a good plan to dig up a few rows across the field and see if the hills are in line.

4. Adjust the distance between rows to the desired width. Corn planters are usually assembled with the furrow openers spaced 42 ins. apart. If it is desired to increase or change this width, the several adjustments must be made as follows:

(*a*) Width between furrow openers.
(*b*) Width between drive wheels.
(*c*) Spacing between buttons on the check wire (if corn is planted in check rows). This would necessitate another roll of wire.

The three adjustments just mentioned should all be spaced equally. In addition to these, the pinions on the feed shaft must be moved, and the marker adjusted. The distance from the center of the planter to the line made by the marker should always be twice the distance between the rows. The operator drives so as to keep the pole directly over the last marker line.

5. Stake out the check wire and begin planting.

(*a*) Place roll of wire in the reel holder.
(*b*) Set one anchor stake back from the edge of the field, as shown in Fig. 114, *a*. (If the stakes cannot be set beyond the edges of the field, headlands must be left.)
(*c*) Attach wire from the reel to this stake.
(*d*) Drive straight across the field, allowing the wire to unreel. Keep close to the edge of the field. Keep enough tension on the reel to make the wire tight.
(*e*) When the opposite end of the field is reached, disconnect the wire and remove the reel from the planter.
(*f*) Turn the planter around and get it in position to plant the first two rows (position 2 in Fig. 114).
(*g*) Drive in the second anchor stake directly behind the center of the planter, as shown in Fig. 114, *b*.

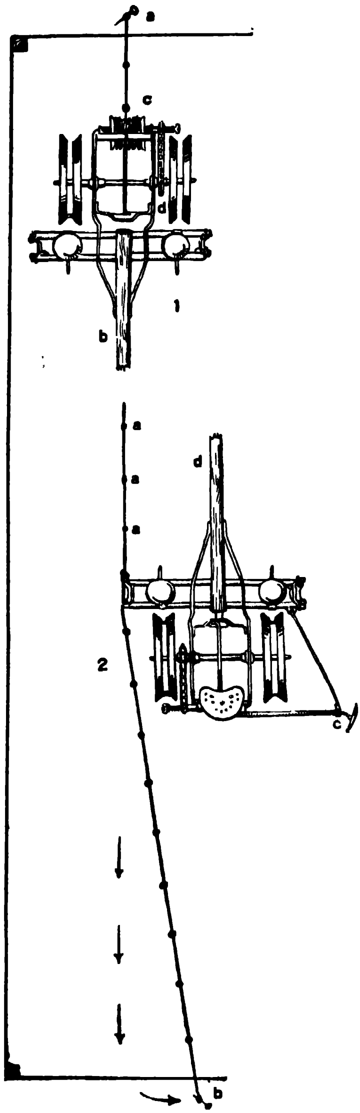


FIG. 114.—Staking out wire for operation of check-row corn planter.

(h) Draw the wire tight and attach it to the stake.

(i) Put the marker in position. Fill the hoppers. Lower the furrow openers. Put the wire through the check head, and plant across the field.

(j) Just before reaching the first anchor stake, release the wire from the check head. Raise the marker.

(k) Turn the planter around so that the pole is over the marker line.

(l) Reset the stake behind the center of the planter. This must be done at each end of the field, each time, after the planter has been turned around.

6. Adjust the depth of planting. The depth of planting is controlled by the lever which raises or lowers the furrow openers. Penetration is secured by means of the pressure of a heavy spring which acts when the furrow openers are lowered.

7. Set the variable-drop to plant the desired number of kernels per hill. This is controlled by a small foot lever in front of the operator's seat.

The notches with which this lever engages are numbered 2, 3, and 4, the number indicating the number of kernels per hill.

8. Set the rate of flow of fertilizer. This may be regulated by changing the size of the opening between the hopper and the delivery spout, or by changing the sprocket which drives the fertilizer shaft.

9. Plant the main body of the field.

10. If headlands have been left, remove the wire and plant across them. This is done without the use of the check wire. A foot pedal is provided for the purpose of operating the checking fork. As the planter is driven across the field, the foot pedal is used to drop hills in line with the rows.

Job No. 16

TO OPERATE THE CHECK-ROW CORN PLANTER FOR DRILLING CORN

(Check wire is not used.)

Operations Necessary to Perform the Job.

1. Fill hoppers with seed. Set planter to give proper interval between seeds.
2. Lock valves open.
3. Lower furrow openers.
4. Put marker in position.
5. Drive straight across field and plant first two rows.
6. Complete return trip across field, and continue planting.

Description of Operations.

1. Fill the hoppers with seed and drive to the side of the field where planting is to begin. Set the planter to give the proper interval between seeds, by changing seed plates or driving sprockets.

2. Lock the valves open with the foot lever. The valves are always open (out of action) while drilling.

3. Lower the furrow openers. This engages the feed shaft so that the seed plates begin turning.

4. Place the marker in working position on the side toward the center of the field.

5. Drive straight across the field. If the edge of the field has no straight boundary line to follow, the operator should set a mark at the opposite side, as a guide. It is important that the first rows be straight, as all the rest are apt to be the same as the first.

6. Upon reaching the opposite end, raise the furrow openers and marker.

7. Turn the planter around into position for the return trip, with the pole above the marker line.

8. Lower the furrow openers, reverse the marker, and complete the return trip.

9. Continue back and forth across the field in the same manner.

CHAPTER V

CULTIVATORS

Cultivators are used for tillage, after the crop has grown to such an extent that the harrow or weeder cannot be used. Cultivating stirs and aerates the soil, kills weeds, mulches the surface, and makes the plant food more easily available. Cultivators must be accurately controlled, properly adjusted, and fitted with the correct types of cultivating tools. The cultivator stirs the soil very near the roots of the growing crop. If it is set too deep, or if it is not carefully guided, the growth of the crop may be retarded and the yield reduced. This implement is used chiefly for cultivating crops grown in rows, such as corn, cotton, potatoes, etc.

Types and Sizes.—Cultivators are manufactured in a great many different styles and sizes. With the exception of the plow, no other single class of farm machines has so great a divergence of types. Many factors affect the problem of properly selecting a cultivator of suitable size and construction. The kind of crop, the soil conditions, the acreage, the power available, and the amount of rainfall are some of the important factors to be considered in the choice of a cultivator.

The cultivation given the early growth is different from that required later.

Because of all these factors, a large number of types and sizes are available.

The first time a crop is cultivated, the cultivating tools are set to penetrate more deeply than in later cultivations when the root system is better developed. Special tools, called surface blades, may be secured for late cultivations. Certain

crops require hilling up; for this purpose disk cultivators or special hilling shovels are often used. Cultivation is necessary in all types and sizes of fields, from the smallest garden to the largest field of corn or cotton. This wide variety of conditions has caused the development of a great number of sizes and kinds of cultivators and a great many attachments and tool equipments for them.

Only those types that are in general use will be discussed here.

Cultivators may be divided into three classes, as follows:

1. Wheel hoes.
2. One-horse or between-row cultivators.
3. Straddle-row cultivators.

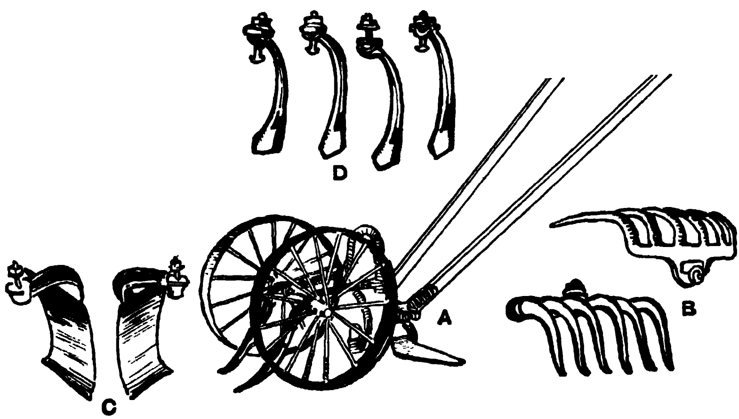


FIG. 115.—Wheel hoe and equipment.

1. Wheel Hoes (Fig. 115).—Wheel hoes are operated by hand. Figure 115, *A* shows a wheel hoe with a double wheel. They are also furnished with single wheels. Figures 115, *A*, *B*, *C* and *D* show the cultivating tools that are usually furnished with this type. They include a pair of hoes, four cultivator teeth, one pair of rakes, and a pair of plows. Many other tools may be obtained for use with the wheel hoe.

Work can be done much faster with this type of tool than with the hand hoe. The many different attachments make it useful for a variety of jobs.

2. One-horse Cultivators (Figs. 116 and 117).—This type of cultivator is drawn by one horse.

Figure 116 shows a fourteen-tooth cultivator. The teeth in this cultivator can be raised or lowered, and adjusted for different angles by means of the tooth clamp.

The width of the cultivator is adjustable with the lever

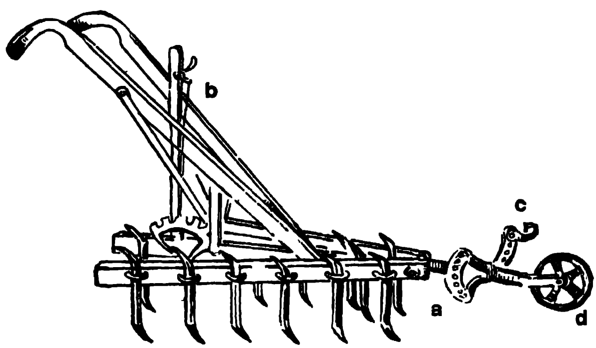


Fig. 116.—One-horse cultivator, 14-tooth.

(Fig. 116, *b*). This adjustment is very desirable in garden work as the width of the rows varies greatly.

Figure 117 shows another type of one-horse cultivator equipped with shovels. The number of shovels used varies from five to nine. Double-edged shovels (Fig. 117, *b*) are usually furnished, so that the shovel may be reversed to secure a new cutting edge. The shovels are attached to the shank (Fig. 117, *c*) with one bolt. A lever (Fig. 117, *d*) is provided for adjusting the width of the cultivator.

The single-tree is connected to the draft hook (Fig. 117, *e*). This may be adjusted vertically by means of the holes in the draft iron.

A gauge wheel (Fig. 117, *f*) is supplied to aid in controlling

the depth. The wheel is also a convenience when one is transporting the cultivator to and from the field.

A wide variety of cultivating tools may be obtained for use with these cultivators.

One-horse cultivators are drawn between the rows, not astraddle of the row.

3. Straddle-row Cultivators (Figs. 123, 124, 125).—Straddle-row cultivators are built in one-row and two-row sizes. As

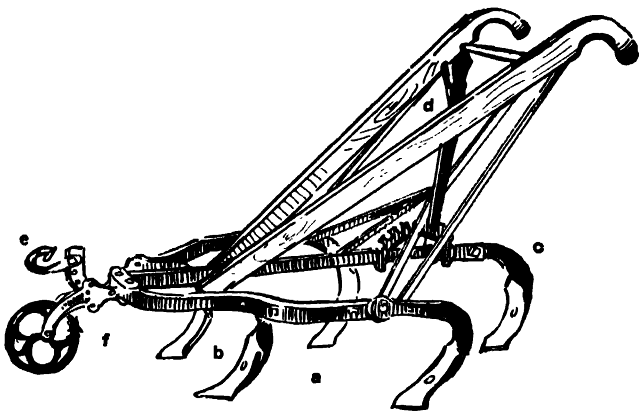


FIG. 117.—One-horse cultivator with reversible shovels.

the name signifies, this cultivator straddles the rows, that is, the cultivating tools work on each side of the row.

Either walking or riding cultivators may be obtained. Some are made so that the operator may either walk or ride. These are called combination riding and walking cultivators.

WALKING CULTIVATORS

(Straddle Row)

Walking cultivators (Fig. 118) are made only in the one-row size. They are cheaper than riding cultivators, and are preferred by many farmers, especially for use when the plants are young and small.

CONSTRUCTION AND PRINCIPAL PARTS OF WALKING CULTIVATORS

1. Wheels (Fig. 118, *a*).—Two steel wheels are used. The hub has a removable wheel box similar to that used in plow wheels. The wheel is retained on the axle by means of a pin and an adjustable washer. The hub cap (Fig. 118, *b*) is used as a grease cup. The distance between the wheels may be changed so that the cultivator may be used for wide or narrow rows.

2. Gangs (Fig. 118, *c*).—The gangs or rigs carry the shovels or cultivating tools. They are made of flat or channel steel or round pipe. The front ends of the gangs are connected to the the arch (Fig. 118, *d*) by an adjustable coupling. These couplings are provided with cone-shaped bearings. A worn bearing may be taken up by tightening the nut at the top of the coupling. The gang couplings allow the gangs to swivel or swing in and out easily. Thus the operator, by manipulating the handles (Fig. 118, *e*), can cultivate the rows very accurately.

3. Arch (Fig. 118, *d*).—The front end of the gangs connects to the arch, the width of which is adjustable. The upper ends of the arch arms may be slipped in or out of the bracket mounted under the pole. This adjusts the cultivator for wide or narrow rows.

The lower ends of the arch in walking cultivators are used as the axles of the wheels.

4. Eveners.—Two-horse eveners are supplied with walking cultivators. The evener (Fig. 118, *f*) is made of steel and is fastened to the pole (Fig. 118, *g*) with a clevis. A steel pendant (Fig. 118, *h*) is hooked over each end of the evener bar and hangs downward. The lower ends of the pendant are connected by links (Fig. 118, *i*) to an adjustable draft iron, which is located at the point where the gangs connect to the arch. The height of the single-trees (Fig. 118, *j*) is adjustable by means of the series of holes in the pendant. If the single-trees are placed high, the pull is downward and better penetration is

thus secured in hard ground. A low hitch has a tendency to pull upward, thus lessening the penetration.

5. Lifting Springs (Fig. 118, *k*).—The lifting springs aid the operator in lifting the gangs out of the ground. The tension of these springs should be adjusted so that the gangs balance when in the raised position, that is, so that the tension of the springs alone is enough to hold up the gangs. The lifting springs are connected to the gangs in such a way that they exert little or no lifting power when the gangs are in the ground; it is only

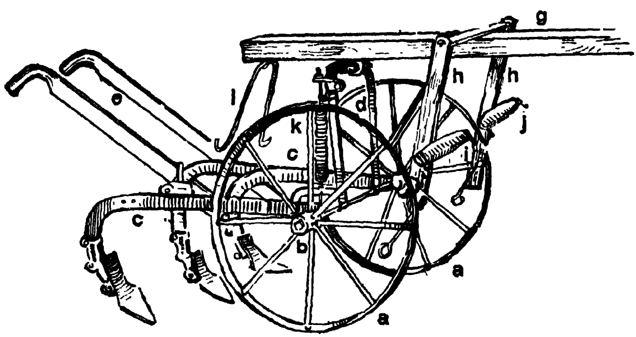


FIG. 118.—Two-horse walking cultivator.

after the operator has started to lift them that the action of the springs becomes effective.

6. Hang-up Hooks (Fig. 118, *l*).—The hang-up hooks support the gangs when they are in the raised position. They should always be kept in this position when the cultivator is not in use.

7. Pole (Fig. 118, *g*).—The pole is made of wood. The rear end of the pole is bolted to the arch and is supported by braces from the lower end of the arch.

8. Handles (Fig. 118, *e*).—Steering or guiding the gangs is accomplished by means of the handles. As each gang is independent of the other, two handles are provided. The handles are usually connected to the gangs by an adjustable casting, so

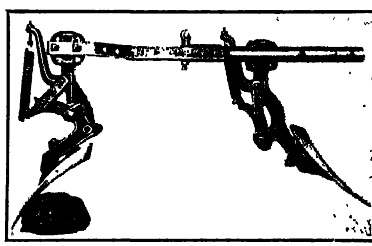
that they may be raised, lowered, or turned in or out as desired by the operator.

9. Attachment of Shovels.—The cultivating shovels, or teeth, are attached to the gangs by means of the following parts:

(*a*) *Shank.*—The ends of the gang beams are turned downward and are almost vertical. These parts of the gangs are called the shanks (Fig. 129, *a*).

(*b*) *Sleeves.*—The sleeves (Fig. 129, *b*) are slipped on to the shank and secured by one bolt. This bolt passes through a slot in the sleeve and through a hole in the shank. The sleeve is also held in place on the shank by means of a wooden pin (Fig. 129, *c*). This pin passes through holes in the sleeve and binds against the back of the shank. This is the " break-pin " type of construction. When the shovel strikes a rock or obstruction, the wooden pin breaks. This allows the sleeve to pivot on the bolt, and the shovel passes over the obstruction. The shovel must then be returned to its original position and secured with a new wooden pin.

Some cultivator shovels are provided with " spring trips " (Fig. 119). When the shovel strikes an obstruction, the jar or blow thus caused compresses a spring and the shovel bends backward and passes over the obstruction, as shown in Fig. 119. It must then be returned to its position by the operator. This construction eliminates the necessity of the operator's frequently cutting and fitting wooden break pins. The tension of the spring in the tripping device is adjustable, and the trip must be oiled to prevent the joints from rusting (Fig. 120).

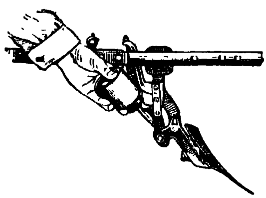


Courtesy of Deere & Co.

FIG. 119.—Action of spring trip.

(*c*) *Shovel.*—The back of the tooth or shovel is fitted with a round split socket. This slips over the round sleeve and is

drawn tight by means of the clamp bolt. One bolt passes through the face of the shovel and is secured by a nut.



Courtesy of Deere & Co.

FIG. 120.—Oiling the spring trip.

10. Shovels (Fig. 121).—Many different types of shovels are used on straddle-row cultivators. In Figs. 121, *A* and *B* are shown the narrow and wide single-pointed shovels; in Figs. 121, *C* and *D* two common widths of double-pointed or reversible shovels. In Fig. 121, *E* is shown a full sweep used for light surface cultivation, and in Fig. 121, *F* a half sweep. The half sweep is also used for light surface

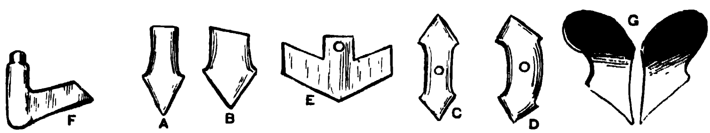


FIG. 121.—Cultivating tools used on straddle row cultivators.

cultivation and is placed on the inside shanks (nearest the row). In Fig. 121, *G* is seen a right and left moldboard hiller. These are used for throwing the soil toward the row, which is called "hilling." A disk hilling attachment is frequently used, particularly for hilling up potatoes.

11. Shields or Fenders.—In Fig. 122, *A*, *B* and *C* are shown three common types of shields or fenders, namely, the revolving, solid, and open types. These are attached to the cultivator gangs on the inside of the center shovels. They are used chiefly during early cultivations, to protect the young plants and to keep them from being covered by the

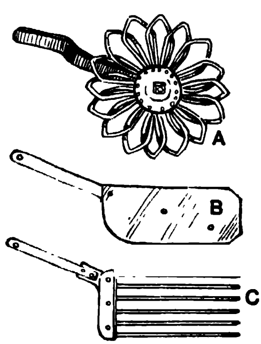
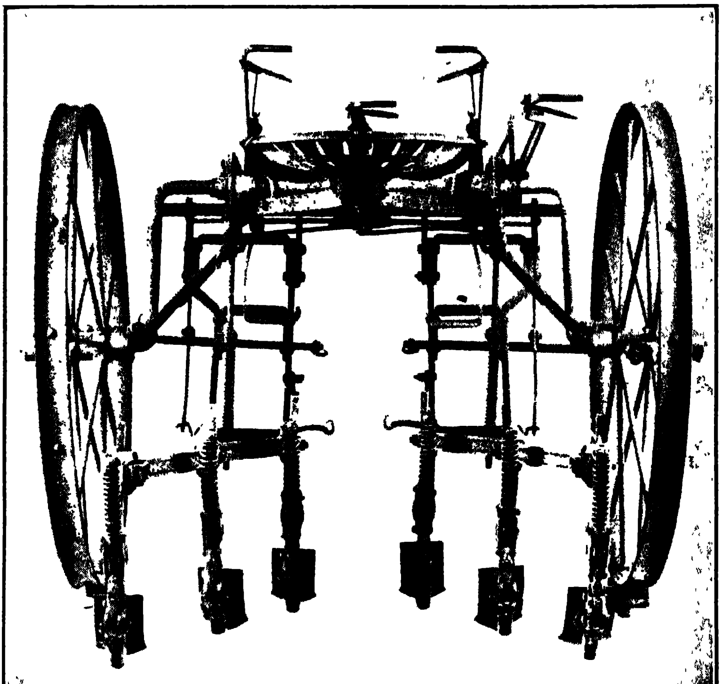


FIG. 122.—Shields or Fenders.

soil. The open type and the revolving type have a desirable pulverizing effect on the soil.

RIDING CULTIVATORS

Riding cultivators are made in both the single-row and double-row sizes. There are three types of riding cultivators.



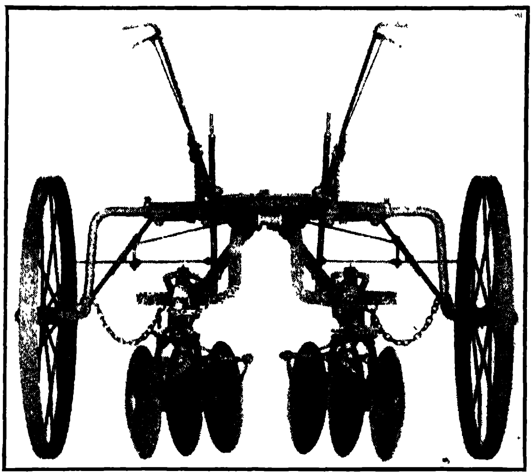
Courtesy of Oliver Chilled Plow Co.

FIG. 123.—Single-row riding cultivator, 6-shovel type.

1. Shovel Cultivator (Fig. 123).—This type of cultivator is equipped with blades or shovels such as those illustrated in Fig. 121. The shovel cultivator is the most widely used of all three types. It is a general-purpose implement. Because of

the wide variety of shovels and attachments that are available, and the wide range of adjustments possible, this cultivator can be used under many different conditions.

2. Disk Cultivator (Fig. 124).—The disk cultivator is used to advantage on fields that have a large amount of grass or running vines growing between the rows. Fields that are infested with "quack grass," wild morning glory, etc., can be controlled with the disk cultivator. The revolving disks cut



Courtesy of Oliver Chilled Plow Co.

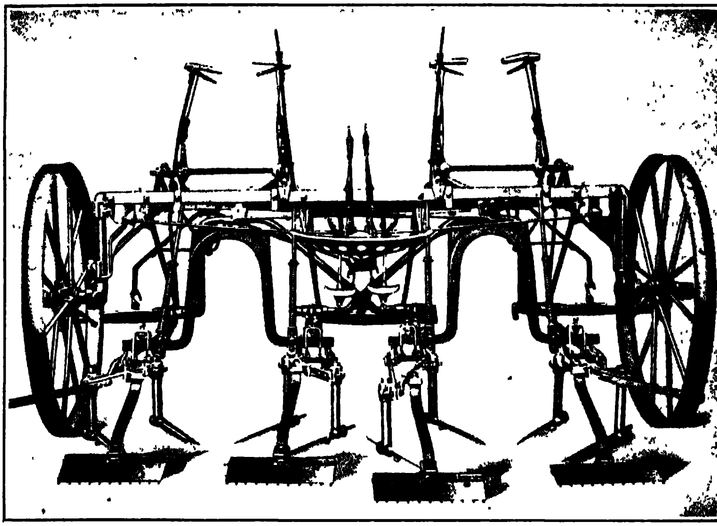
Fig. 124.—Single-row disk cultivator.

and turn up the roots so that they may be destroyed by exposure to the sunlight. Disk cultivators do excellent work in hilling up crops. The disk gangs have a wide range of adjustment. They may be set to throw the soil either toward or away from the plants.

Leveling bars are used behind the disks when it is desired to keep the soil level.

3. Surface Cultivators (Fig. 125).—The surface cultivator is fitted with long blades. These do not penetrate deeply,

but slice off weeds and work the surface of the soil. This type of shallow cultivation is very desirable at a late stage in the



Courtesy of International Harvester Co.

FIG. 125.—Two-row surface cultivator.

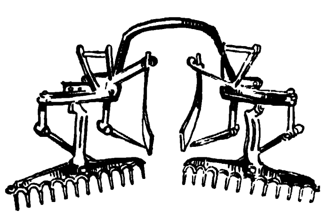


FIG. 126.—Surface cultivator attachment.

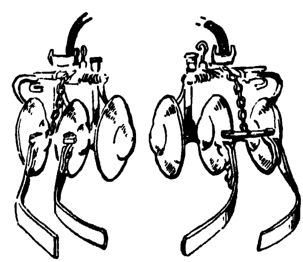


FIG. 127.—Disk cultivator attachment with levelers.

growth of the crop, when the root system of the plant is well developed.

Surface-cultivator attachments (Fig. 126) and disk attach-

ments (Fig. 127) may be secured for shovel cultivators. The construction of the frame, wheels, lifting levers, etc., is very much the same for all three types. For this reason a detailed description of the construction of only one type of riding cultivator will be given here.

CONSTRUCTION AND PRINCIPAL PARTS OF RIDING CULTIVATOR

(Shovel Type)

1. Wheels (Fig. 129, *a*).—Riding-cultivator wheels are higher than those used on the walking cultivator. The wheels are usually about 40 ins. in diameter and have tires about $2\frac{1}{2}$ ins. in width. The construction of the wheel and axle is illustrated in Fig. 128. At the inner end of the axle (Fig. 128, *a*) the sand box or thrust bearing (Fig. 128, *b*) is attached. This is built in halves (one half is removed in Fig. 128) and is clamped to the axle with bolts. The wheel box (Fig. 128, *c*) is bolted to the hub of the wheel, as in plow wheels. The inner end of the wheel box ends in a collar which is retained in a recess in the thrust bearing. The opposite end of the wheel box is threaded to receive the hub-cap grease cup (Fig. 128, *d*).

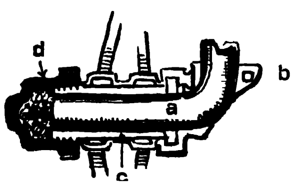


FIG. 128.—Cultivator wheel hub and axle.

This type of wheel cannot be adjusted in or out on the axle.

2. Gangs (Fig. 129).—The construction of the gangs is very similar to that used for walking cultivators. Riding-cultivator gangs may be equipped with four, six, or eight shovels, the six-shovel equipment being the most common. Figure 129 indicates the location of the shovels on the six-shovel cultivator.

Two principal methods of attaching the gangs are used in riding cultivators. One method, which is the same as that used for walking cultivators, allows the gangs to pivot at the front end. The other method provides a rigid attachment between the front ends of the gangs and the bar or arch that moves them

(Fig. 130). This attachment does not permit the gangs to swing at the front ends.

3. Cultivator Control.—There are several different methods of controlling or manipulating the gangs on riding cultivators. The most commonly used methods will be discussed here.

(*a*) *Direct Foot Control.*—In this type of cultivator, each

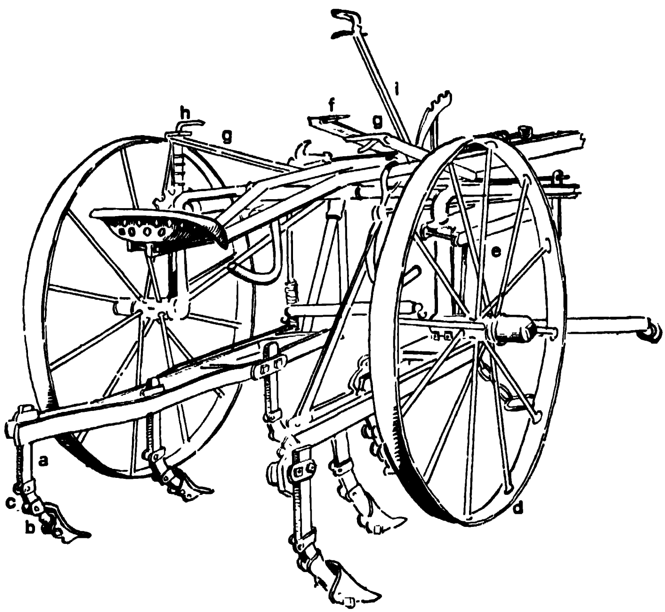


FIG. 129.—Construction and principal parts of 6-shovel riding cultivator.

gang is independent of the other. They pivot at the front end as in walking cultivators. The operator controls the gangs entirely by the action of his feet, for which stirrups are provided on the gangs.

This type of cultivator is favored by many farmers, as very accurate and close work may be done with it. This method of control is harder work for the operator, as he manipulates the gangs directly, without the aid of levers.

(*b*) **Seat Shift or Pivot Frame.**—In this type of cultivator the gangs are controlled by the operator by means of the swinging motion of the seat. The frame of the cultivator is attached to the rear end of the tongue, and the rear end of the tongue is supported by a large roller. The seat is connected by long steel bars to the front of the frame. These bars are pivoted under the axle, and the seat is thus made to act as a lever. A slight pressure by the operator in either direction on the seat causes the gangs to shift.

Foot rests are provided on the gangs to make it easier to put pressure on the seat.

(*c*) *Parallel Gangs: Foot Shift* (Fig. 130). In this type the gangs are rigidly connected at the front ends to the gang bar (Fig. 130, *e*). A shifting bar (Fig. 130, *f*) is bolted to the gang bar. This bar is supported above the frame by rollers (Fig. 130, *a*). The action of the foot levers (Fig. 130, *b*) is transmitted to this bar by chains and pulleys (Fig. 130, *c*). Both gangs are moved as a unit; they are rigid and always parallel.

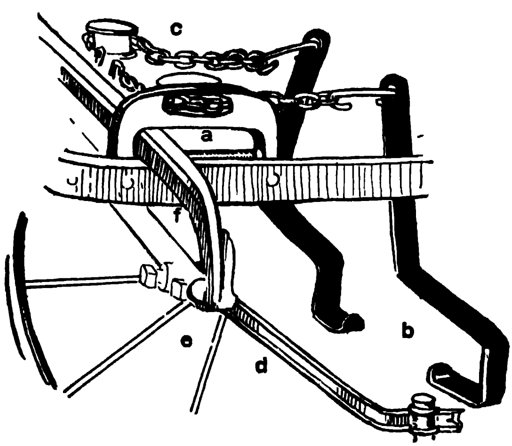


FIG. 130.—Construction of parallel gang, foot-shift control and combination control.

(*d*) *Pivot Axle.*—The foot pedals are connected to the axles. A slight pressure on either foot lever shifts the axle and changes the direction of travel of both wheels, which, of course, control the gangs. The pivoting-wheel type is particularly useful for hillside work, and also very helpful in steering the

cultivator. Where short turns at the ends of the rows are necessary, the pivoting wheels are very desirable.

(*e*) *Combination Control.*—A combination of the methods described in (*c*) and (*d*) is quite widely used. Pressure applied to the foot pedal not only pivots the axle but also moves the gangs sidewards. The pivot-axle method alone is rather slow. When the operator presses on the pedal, he simply changes the direction of travel of the wheels. Before the gangs move to one side the whole cultivator must be drawn forward by the horses. With the combination method, (*c*) and (*d*), as soon as the operator pushes on the foot pedal he not only changes the direction of travel of the wheels but, at the same instant, the gangs are moved sidewards. This method is quick, and the problem of dodging the plants in crooked rows is made much easier

The combination is made by connecting the arched bar (Fig. 130, *f*) to the axle-crank arm (Fig. 129, *e*).

This method of control is used very largely on two-row cultivators.

4. Balance Frame.—As the weight of all parts of the cultivator is supported by two wheels, it is necessary that this weight be evenly distributed. When the gangs are taken out of the ground, their weight, which was on the ground, is added back of the axle. This has a tendency to make the pole tip up.

Most cultivators are built to balance in any position. Two methods by which cultivators are balanced will be discussed here.

(*a*) By cranking back the axles as the gangs are raised. This means that the device or lever used for lifting the gangs from the ground is connected to the axles. The axles crank backward as the gangs are lifted, balancing the weight thus added.

(*b*) By shifting the entire cultivator frame forward as the gangs are raised. This is accomplished by suitable connections between the gang-lifting lever and the frame. When the gangs are raised, the whole frame, including the driver's seat, moves forward, thus balancing the machine.

5. Levers (Fig. 129).—Riding cultivators are usually equipped with several levers, although some leverless riding cultivators are made.

The following levers are usually supplied:

(*a*) *Master Lever* (Fig. 129, *f*).—The master lever raises or lowers both gangs as a unit. It is often connected to the axles, so that as the gangs are raised the axles are cranked backward, in order to preserve the balance of the cultivator. In many cultivators this lever is attached in such a way that as soon as the lever latch is released the pull of the horses raises the gangs. This is called a " horse lift." The master lever is used at the end of the rows for raising and lowering the gangs. It is sometimes called the balancing lever.

(*b*) *Gang Lever* (Fig. 129, *g*).—A gang lever is provided for each gang. This lever is used to adjust the depth of the shovels. Either gang may be raised independently of the other. This is often necessary to clear the gang of trash or to pass over an obstruction.

(*c*) *Spacing Lever* (Fig. 129, *h*).—A spacing lever is provided on some riding cultivators. It is used to space or change the distance between the gangs so that the cultivator may be quickly adjusted for any width of row.

(*d*) *Pole Lever* (Fig. 129, *i*).—A pole lever is used on some riding cultivators. This lever makes it possible to keep the cultivator frame running level under all conditions. In cultivating up and down hill this adjustment is helpful in keeping the front and rear shovels penetrating to an equal depth. It is also a convenient means of leveling the frame when changing to horses of a different height.

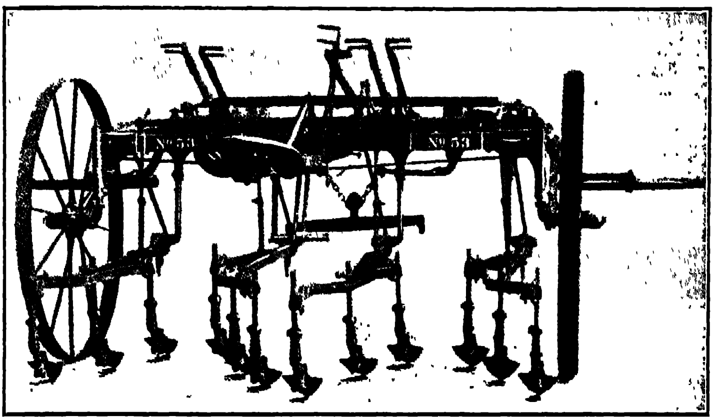
TWO-ROW CULTIVATORS

A two-row cultivator is shown in Fig. 131. When used with horses it may be equipped with a forecarriage, which carries the weight of the front part of the machine.

Two-row cultivators are usually controlled and steered by the combination method described on page 177. This means

that the action of the foot pedals (Fig. 130, *b*) causes the gangs to shift sidewise and the wheels to pivot simultaneously

A master lifting lever is usually provided so that all the gangs may be lifted at once. A spacing lever makes it possible to adjust the gangs to different widths between rows; this lever is used to adjust the spread of the gangs. By means of the



Courtesy of Emerson Brantingham Implement Co.

FIG. 131.—Two-row shovel cultivator.

spacing lever the shovels may be brought toward the plants or moved farther away from them.

Each gang is also provided with a separate depth lever by means of which it may be set at the desired depth or may be lifted from the ground to be freed from trash.

Two-row cultivators are equipped with either three-horse or four-horse eveners. Special tractor hitches, such as that shown in Fig. 134, may also be secured. A diagram for the use of a tractor and a two-row cultivator is shown in Fig. 133.

LABORATORY STUDY NO. 8

To study and compare various types of straddle-row cultivators.

Equipment Necessary.—Walking and riding cultivators (several different types): shovel, surface, and disk attachments desirable.

Procedure.

1. Determine which are walking and which are riding cultivators.
2. Study the construction of each cultivator, and determine whether or not shovels, disks, and surface blades can be used interchangeably on the same machine.
3. Answer the following questions:
   (*a*) How are the wheels retained on the axles?
   (*b*) How are the wheels lubricated?
   (*c*) Are the wheel boxes renewable?
   (*d*) Are the wheels used in controlling or guiding the shovels?
4. Operate each of the levers and determine the purpose of each.
5. How is the distance between the gangs adjusted?
6. How is the distance between the wheels (called the tread) adjusted?
7. What method is used for controlling or steering the shovels (or cultivating tools)?
8. How are the gangs or rigs connected to the frame?
9. What method of balancing is used?
10. Is it possible to adjust the balance to suit different operators?
11. What device is used to aid in lifting the gangs?
12. What kind of shields are used?
13. What type of shovels are used?
14. Are the shovels released by a spring trip or by a wooden break pin, when an obstacle is struck?

15. Are leveling arms provided on the disk cultivators? (Fig. 127.)

16. Adjust the disks to throw the dirt in. Adjust them to throw it out.

17. What adjustments are provided for setting the surface blades?

18. Are levelers (Fig. 125) used behind the surface blades?

19. Can the levelers be adjusted to throw the dirt away from the corn?

20. How are the shields adjusted?

Job No. 17

TO REPAIR A WHEEL HOE

Operations Necessary to Perform the Job.

1. Repair wheel bearings.
2. Sharpen cultivating tools.
3. Tighten bolts.
4. Grease cultivator tools; paint all other parts.

Description of Operations.

1. Take off the wheels. Clean and oil the wheel bearings. If they are badly worn, new bearing bolts (axles) should be put in.

2. Sharpen all the cultivating tools on the grindstone. Grind them so as to retain their original shape or bevel. These tools may be sharpened with a file if a grindstone is not at hand.

3. Tighten all bolts.

4. Paint all parts, except the cultivating tools, which should be coated with heavy grease.

Job No. 18

TO REPAIR A ONE-HORSE CULTIVATOR

Operations Necessary to Perform the Job.

1. Inspect and repair gauge wheel.
2. Sharpen shovels.
3. Tighten bolts and brace rods.
4. Lubricate and adjust lever.
5. Grease shovels and paint all other parts.

Description of Operations.

1. Remove the gauge wheel. Clean and oil the bearing. Put in a new bearing bolt or axle if necessary.

2. Remove and sharpen the shovels on the grindstone. These are ground on the back side.

3. Tighten the bolts that connect the shovel shanks to the beams.

4. Tighten all brace rods, so that the cultivator is rigid.

5. Operate the adjusting lever (Fig. 116, *b*). Oil the lever detent or plunger and see that the lever functions properly.

6. Cover the shovels with a coating of oil or grease.

7. Paint all parts of the cultivator.

Job No. 19

TO OVERHAUL AND REPAIR A STRADDLE-ROW CULTIVATOR

Operations Necessary to Perform the Job.

1. Inspect wheel bearings and alignment of wheels.
2. Tighten all bolts and rivets.
3. Test action of each lever.
4. Adjust lifting springs.
5. Sharpen cultivating tools.
6. Inspect and adjust all steering control parts.
7. Cover shovels with grease.
8. Paint all other parts.

Description of Operations.

1. Test the wheel bearings by rocking the wheel on the axle to determine the amount of wear. Remove the wheels, clean and lubricate the axles thoroughly. Replace the wheel boxes (Fig. 128, *c*) and collars (Fig. 128, *b*) if necessary. See that the wheels stand plumb and " toe in " slightly at the front.

2. Tighten all frame bolts, rivets or bolts in the gangs, gang couplings, etc.

3. Operate each lever. See that each works freely and functions properly. Oil the lever detent (or catch) to prevent its becoming rusted tight.

4. Tighten the bolts or rivets that secure the lever ratchets.

5. Adjust the tension of the lifting springs so that the gangs may be raised and lowered easily.

6. Remove the shovels. Sharpen them on the grindstone by grinding on the reverse side of the shovel. Try to maintain the original shape or bevel. Remove any rust spots with emery paper.

7. Sharpen disks and overhaul disk bearings (on disk cultivator) in the same manner as described for disk harrows.

8. Remove and sharpen surface blades (Fig. 125) on the

grindstone, grinding them on the under side. Try to maintain the original shape.

9. Examine the wooden break pins (on shovel cultivators). Replace any that appear worn. Make up a supply of wooden pins and put them in the tool box of the cultivator.

10. Examine all parts of the control device; foot pedals, cranks, chains, couplings, etc. Take up all lost motion and replace worn parts.

11. Coat the shovels, disks, or blades with oil or grease to prevent rust.

12. Paint all other parts of the cultivator.

Job No. 20

TO OPERATE A WHEEL HOE

Operations Necessary to Perform the Job.

1. Select proper tools.
2. Keep tools and tool holder securely fastened.
3. Regulate depth of cultivation.
4. Adjust leaf guards.

Description of Operations.

1. Select the proper tools for the type of work to be done, (see page 164 and Fig. 115).

2. Keep the wheels well lubricated. See that the bolts which attach the tool holder to the handles and arch are kept tight. Otherwise the tools will not be held rigidly and poor work will result.

Each tool has a small square lug that fits into a slot in the tool holder (Fig. 115, *A*). The nuts securing the tool must be kept tight in order that the tool may be kept in proper alignment.

3. The depth of penetration is controlled by the amount of downward pressure the operator puts on the handles. Wheel hoes are pushed forward in strokes of a few feet at a time. More accurate work can be done in this manner than by pushing the wheel hoe steadily forward.

4. The leaf guards should be adjusted so that they turn the leaves or vines away from the wheels, thus preventing their being damaged (Fig. 115).

Job No. 21

TO OPERATE A ONE-HORSE CULTIVATOR

Operations Necessary to Perform the Job.

1. Drive between rows.
2. Adjust hitch.
3. Change width of cultivator as desired.
4. Secure proper penetration of cultivating tools.

Description of Operations.

1. These cultivators are drawn between the rows by one horse. The horse travels down the center of the space between adjoining rows.

2. The hitch may be adjusted up or down in the draft iron. It should be placed low if shallow cultivation is desired, and high if deep cultivation is desired.

No horizontal or lateral hitch adjustment is necessary, as the center of resistance is directly in line with the center of power.

3. The width of the cultivator is adjusted by means of the lever. It is usually set wide enough to cultivate thoroughly all the space between the rows.

4. The penetration, or depth of cultivation, is dependent upon the following factors:

(*a*) Sharpness of shovels.
(*b*) Angle of shovels.
(*c*) Position of hitch in draft iron.
(*d*) Condition of soil.

If the soil is wet and sticky, it will not scour off the shovels and good cultivating will be impossible.

OPERATING STRADDLE-ROW CULTIVATORS

Cultivating accomplishes a number of different purposes. Because these purposes are so different, various types of cultivators and various attachments and adjustments are necessary. Each crop may be cultivated several times during the season. The conditions existing during early cultivations are quite different from those encountered later.

Early Cultivation.—The shovels (or disks) may be set quite deep for early cultivation. The gangs may be set close together so that the ground near the plants is cultivated. Shields may be used in early cultivations to protect the small plants from being covered by the soil. Shovels should be set straight so that the soil is left level.

Later Cultivation.—As the root system of the plant develops, cultivation must be more shallow. Deep cultivation when the plants are well grown injures the roots and reduces the yield.

The gangs should be spaced farther apart than for early cultivation. Half sweeps are often used in place of the two inside shovels (Fig. 121, *F*), in order to prevent injury to the roots. The outside shovels may be turned slightly on the shanks so as to throw the soil in toward the row.

Surface cultivators or sweeps are often used for late cultivation. They work only the surface, slice off the weeds, and mulch the top soil well (Fig. 121, *E*).

Final Cultivation.—The final tillage operation with many row crops is hilling. This consists in throwing the soil toward the row so as to form a ridge or hill.

Hilling may be accomplished efficiently with a disk cultivator or by using hilling shovels on a shovel cultivator. The disks are given a large angle and are set to throw the soil in.

Hilling is the final tillage operation. It should not be done until the foliage of the plants is well developed. Hilling leaves a trench in the center of the space between the rows, from which evaporation would be rapid were it not shaded by the plant foliage.

Job No. 22

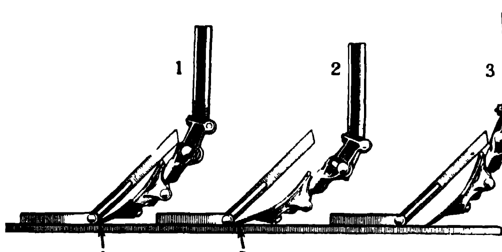
TO OPERATE A STRADDLE-ROW CULTIVATOR

Operations Necessary to Perform the Job.

1. Select suitable cultivating tools for work to be done.
2. Lubricate all working parts of cultivators.
3. Adjust hitch and regulate height of pole.
4. Adjust machine to suit operator.
5. Set distance between wheels.
6. Start cultivating at one edge of field.
7. Space gangs.
8. Regulate depth of cultivation.
9. Keep cultivating tools free from trash.
10. Continue cultivating according to some well-proven method (see example, page 191).

Description of Operations.

1. The selection of the cultivating tools will depend upon the kind of work to be done, as explained on page 170. If shovels



Courtesy of Deere & Co.

Fig. 132.—Adjusting angle of cultivator shovels.

are used they must be properly set. Figure 132, *1* shows a shovel set at the correct angle. The shovel shown in Fig. 132, *2* is set at too small an angle, and the one in Fig. 132, *3* at too steep an angle. Proper penetration could not be secured with either of the latter settings. Set the shields as explained on page 170.

2. Lubricate all bearings, rollers, gang couplings, lever latches, etc. Remove hub caps and grease axles.

3. Adjust the hitch and regulate the height of the pole. The single-trees are adjustable vertically in the pendants. Hitching the single-tree high has a tendency to pull the front shovels deeper into the ground and the rear shovels out of the ground. Hitching low has the opposite tendency. For average conditions the hitch should be so adjusted that the line of the traces, if extended, would pass through the pendant and strike the ground just at the rear of the front shovel.

The height of the pole must be adjusted so that the gangs are level, otherwise the shovels will not penetrate equally. If the pole tilts upward the rear shovels will penetrate more deeply than the front ones, and the opposite will be true if the pole tilts downward. Some cultivators have a pole lever for this adjustment. Otherwise such adjustment must be made by regulating the length of the straps attaching the neckyoke to the pole.

No horizontal hitch adjustment is required.

4. Adjust the machine to suit the operator. The tension of the lifting springs should be adjusted so that lifting and lowering is made as easy as possible.

The balancing device (axle crank or frame shift) should be adjusted to suit the weight of the driver.

There should be no tendency of the pole to tip up when the gangs are raised. On some machines a lever is provided for balancing. In others the seat may be moved to any position along the seat bars to suit the convenience of the operator and to balance the machine. On some cultivators foot pedals are provided with extensions so as to be adjustable for the comfort of the driver.

5. Set the distance between the wheels (the tread). This must be the same as the distance between the rows, in order to allow each wheel to travel exactly in the center of the space between the rows. This adjustment is made by moving the axles in or out on the frame.

6. Start cultivating at the edge of the field.

7. Space the gangs properly. The spacing may be regulated

by a lever, or it may be necessary to shift the gangs where they are connected to the arch. The gangs should be set so that the cultivating tools will come as near to the row as desired, depending upon the type of cultivation needed (see page 188).

8. Regulate the depth of each gang until the desired penetration is obtained. Thereafter raise and lower the gangs with the master lever (if one is provided).

9. Keep the cultivating tools free from trash. This is done on walking cultivators by raising the gang with the handles and shaking the trash loose. On riding cultivators, an individual gang may be raised by means of its gang lever and the trash shaken off.

10. Start at the first row at the edge of the field with the cultivator astraddle of the row.

11. Drive straight across the field, operating the foot pedals to dodge the plants.

12. Keep the shovels free of trash. When they become clogged up raise the gang and shake the trash free.

13. Continue cultivating according to some well-proven method of laying out the field. Three methods are described in the paragraphs that follow.

Drive as slowly as possible until accustomed to the work. (Accurate work requires slow driving.)

Method No. 1.—Raise the gangs at the end of the row. Turn around short, drop the gangs, and come back on the adjoining row. This method requires a very short turn at each end of the field.

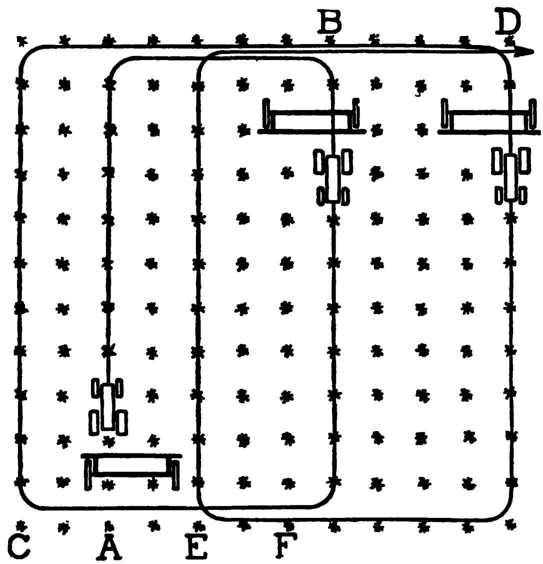
Method No. 2.—Some operators prefer not to make such short turns but skip a row each time, at each end of the field. Thus they cultivate every alternate row as they progress across the field. Then they work back across the field in the opposite direction, cultivating the rows skipped in the first operation.

Method No. 3.—Another common method is to skip one row each time the turn is made toward the uncultivated part of the field. The first row to be cultivated is No. 1, which is at the very edge of the field. The return trip is made on No. 4

row, the next trip across on No. 2. The second return trip is on No. 6 row. Then the rows are cultivated in the following order: 3–8–5–10–7–12, etc.

If twelve rows are indicated on a sheet of paper and a line drawn through them in the order indicated above, this method will be clear. After getting the field started, it consists simply in skipping one row each time on the uncultivated side of the field.

The following directions and diagram for operating a two-row cultivator with a tractor are reproduced by the courtesy of The American Seeding Machine Co. of Springfield, Ohio.

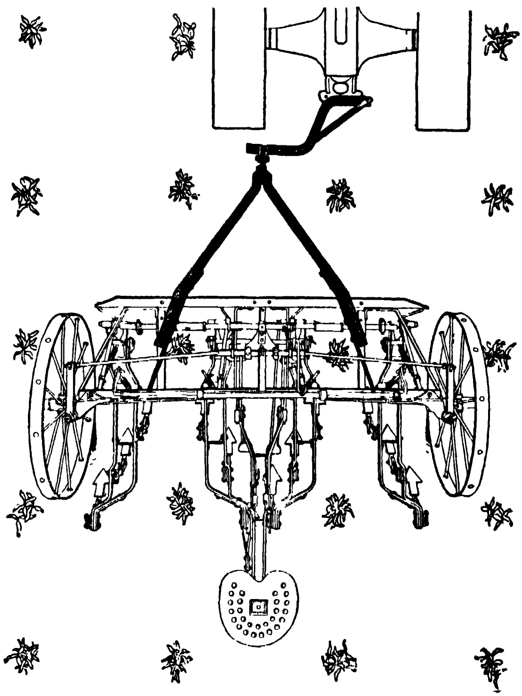


Courtesy of American Seeding Machine Co.

FIG. 133.—Diagram for cultivating with tractor and two-row cultivator.

The method shown in above diagram has proven to be the most practical way of cultivating with a tractor. Start on the left-hand side of the field with tractor straddling the third row (A); turn to the right at end of row and come back straddling the fourth UNCULTIVATED row (B), then go over to first

row (C). Now travel over to twelfth row (D), which leaves two uncultivated rows between B and D. Next straddle the fifth row (E), then go over to twelfth row (D) and start over again, straddling the fourth uncultivated row, etc.



Courtesy of Deere & Co.

FIG. 131.—Tractor hitch for two-row cultivator.

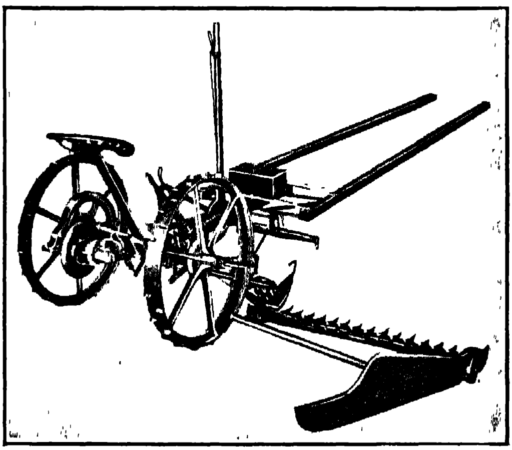
It will be observed in using this method that AFTER GETTING PROPERLY STARTED it is merely a matter of leaving two uncultivated rows each time when turning toward the unplowed part of the field.

If it is desirable to start cultivating from the right-hand side of the field, straddle tractor over sixth row (F), returning in end row (D). Now straddle tenth row (A), which leaves same uncultivated space between B and D, etc.

CHAPTER VI

MOWERS

The chief use of the mower is to cut grass for hay, but it is often used for cutting other crops also. It affords an excellent example of the labor-saving value of farm implements, as the hand method of mowing, which it replaced, was extremely slow and laborious. The operator of a modern 5-ft.-cut mower, drawn by a team of horses, will cut up to 10 acres per day.

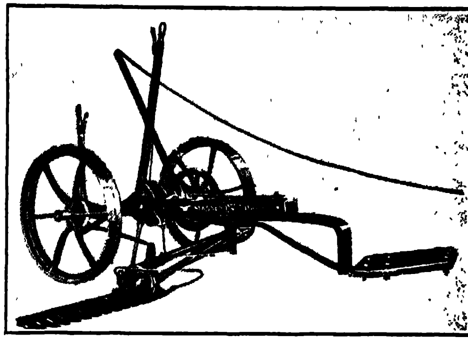


Courtesy of Massey-Harris Harvester Co., Inc.

FIG. 135.—One-horse mower.

The mower must successfully meet many different conditions. It must be capable of cutting fine or coarse grass, and must cut it cleanly, whether the stand is thick or thin. It must be capable of the adjustments and control necessary to cut close to the ground and yet avoid hitting projecting stones,

stumps, or other obstacles. The cut grass must be left in a neatly piled row, or swath, so that it can be easily handled in the later haying operations.

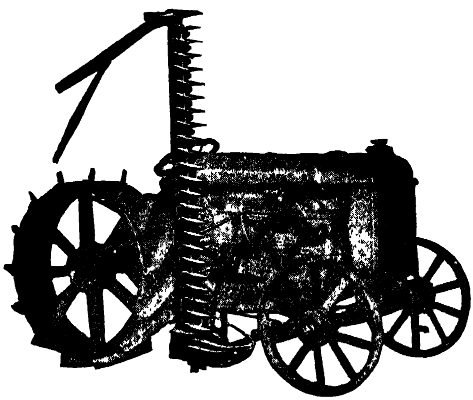


Courtesy of Massey-Harris Harvester Co., Inc.

FIG. 136.—Tractor mower.

Sizes.—The size of a mower is determined by the width of the swath which it cuts. This depends upon the length of the cutter bar (Fig. 137).

A one-horse mower with a $3\frac{1}{2}$-ft. cutter bar is shown in Fig. 135. This machine is used on small farms, lawns, parks, etc. For general farm work, 5- and 6-ft. mowers are commonly used and are drawn by two horses. Eight-foot mowers may also be obtained. These are drawn by two horses or by a tractor.



Courtesy of Roderick Lean Co.

FIG. 137.—Mower cutter bar mounted on tractor.

Figure 136 shows a special tractor mower. With the hitch shown here the cutter bar may be raised and lowered from the seat of the tractor by means of a rope. The hitch is offset sufficiently to keep the tractor from traveling over the standing grass.

Figure 137 shows a cutter bar with control levers carried on

the tractor. The cutting mechanism is driven by power taken from the tractor.

CONSTRUCTION AND PRINCIPAL PARTS

1. Wheels.—The main wheels are both drive wheels. They are made of cast iron. Lugs, cast as an integral part of the rim of the wheel (Fig. 135), cause the wheel to secure good traction and prevent slippage. Slippage of the drive wheels causes the working parts of the mower to stop, with the result that grass is left uncut.

The wheels are retained on the main axle with a take-up washer and cotter pin (Fig. 138, *b* and *c*).

The motion of the drive wheel is transmitted to the main axle by means of ratchets and pawls. The construction is the same as that used in drills (see Chapter III, page 112).

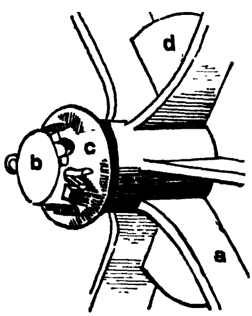


FIG. 138.—Main wheel and axle.

The ratchets form a part of the inside of the wheel hubs (Fig. 138, *d*). A pawl holder with pawls and springs is pinned securely near the right end of the main axle. The pawls driven by the left wheel are carried in the main spur gear (Fig. 140, *b*) which is keyed securely near the left end of the axle.

The pawls should be assembled so that when the drive wheels turn forward they drive the axle. Reversing the drive wheel should allow the pawls to slip over the ratchet. The axle will not move, and a clicking noise will be heard when the wheels are turned backward. Pawls for the left side are not always interchangeable with those for the right, and it is possible to assemble them incorrectly.

2. Main Axle.—The main axle is a straight steel shaft, its size and thickness depending upon the size of the mower. The axle of the 5-ft. mower is about $4\frac{1}{2}$ ft. long.

At each end of the axle a hole is drilled for the cotter pins (Fig. 138, *b*). A key seat is cut near the left end of the axle for securing the main spur gear (Fig. 140, *b*). Another hole provides for pinning the pawl holder near the right end of the axle.

Roller bearings are used at each end of the main axle, as indicated in Fig. 140, *c*.

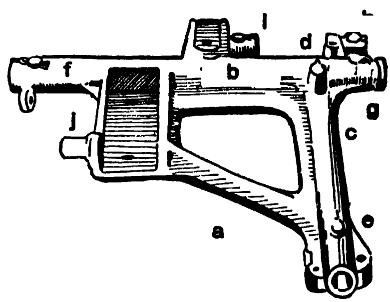


Fig. 139.—Main frame.

3. Frame (Fig. 139).—The main frame is made of one piece of cast iron. The tubular portion (Fig. 139, *b*) forms a housing for the axle, with oil cups (Fig. 139, *d* and *f*). The smaller tube (Fig. 139, *c*) is the housing for the crankshaft (Fig. 142, *a*). The crank shaft forms a right angle with the main axle. Oil cups are placed at each end of the crankshaft. The bearings and oil cups for the short countershaft (Fig. 141) are placed in the main frame as shown in Fig. 139, *h* and *i*. The device for lifting the cutting mechanism from the ground is attached to the short post shown in Fig. 139 *j*.

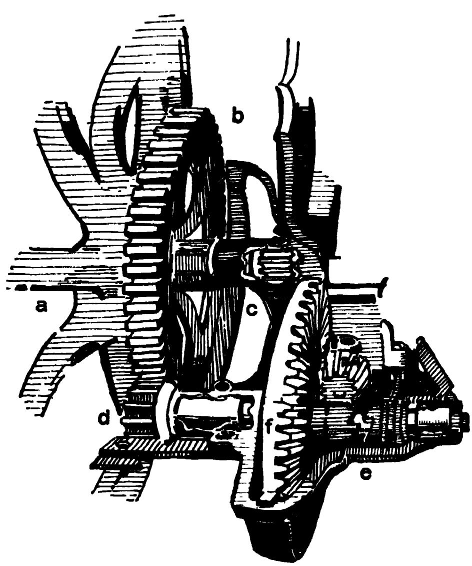


Fig. 140.—Countershaft, gears and clutch.

4. Countershaft, Gears, and Clutch (Fig. 140).—The power from the drive wheels is transmitted by the pawls to the main spur gear (Fig. 140, *b*). This meshes with a small spur pinion (Fig. 140, *d*), which is on the end of the short counter-shaft. Whenever the mower is drawn forward the counter-shaft revolves.

The clutch (Figs. 140, *e* and 141, *b*) is keyed to the counter-shaft and always revolves with it. It may be moved along the shaft by means of the clutch fork (Fig. 141, *c*). This is operated by a small lever (Fig. 141, *d*) near the seat. If the clutch is moved to the left the teeth or lugs of the clutch engage with the large bevel gear (Fig. 141, *e*). This connects the bevel gear to the driving power of the main wheels. The bevel gear turns only when the clutch is engaged.

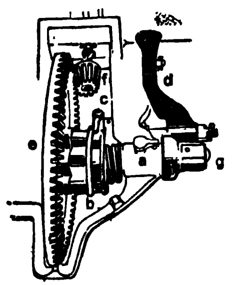


Fig. 141.—Detail of bevel gears and clutch.

A small bevel pinion (Fig. 141, *f*) is keyed to the end of the long crankshaft. This meshes with the bevel gear and is driven by it. An adjustment is provided in most mowers for taking up the wear between the bevel gear (Fig. 141, *e*) and the bevel pinion (Fig. 141, *f*). This adjustment is shown in Fig. 141, *g*.

The bevel gear, pinion, and clutch are enclosed in a gear case which excludes dust and grit. A shield or cover encloses the large spur gear and pinion.

5. Crankshaft and Crank Wheel.—The crankshaft, although at a right angle to the countershaft, is driven by it. This is made possible by means of the bevel gear and pinion (Fig. 141, *e* and *f*).

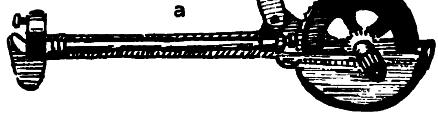
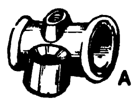


Fig. 142.—Crankshaft and crank wheel.

The crankshaft (Fig. 142, *a*) is a straight steel shaft usually about 16 ins. in length and a little over an inch in diameter.

The bevel pinion (Fig. 141, *f*) is screwed on to one end of the crankshaft, and the crank wheel (Fig. 142, *b*) is keyed to the other end. One bearing is provided at each end of the crankshaft. These bearings are lined with cylindrical babbitt bushings, which must be renewed when worn as they are not adjustable (Fig. 143).

Fig. 143.—Crankshaft bushing.



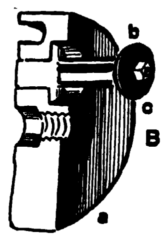


Fig. 144.—*A*, Pitman box; *B*, Cross-section of crank wheel and wrist pin.

The cast-iron crank wheel (Fig. 142, *b*) is keyed or screwed to the front end of the countershaft. A wrist pin (Fig. 144, *b*) is driven through the crank wheel and riveted in place at the position shown. The outer end of the wrist pin is threaded for the wrist-pin nut (Fig. 144, *c*).

6. Pitman (Fig. 145, *a*).—The pitman connects the crank wheel to the cutting knife, or sickle. It is usually made of wood, although iron pitmans are often used.

The connection of the pitman to the crank is made by a renewable box (Fig. 144, *A*). This is known as the pitman box and is lined with bronze or babbitt, where it fits over the wrist pin. This bearing is subjected to severe strain, and will heat up quickly if not well supplied with the proper quality of lubricant. A grease cup is used for the purpose of lubricating it.

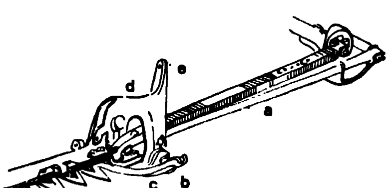


Fig. 145.—Connection of pitman to sickle.

The pitman box is attached to the wood pitman with metal straps and a bolt. The cone-shaped ends of the straps fit into the pitman box as indicated in Fig. 144, *A*. This makes a swivel connection, which greatly lessens the strain on the pitman-box bearing and makes it practically self-aligning.

Metal straps are also used to connect the opposite end of the pitman to the sickle. The ends of these straps have sockets which are sprung over the ball on the end of the sickle. This connection is kept tight by means of the pitman bolt.

The pitman changes the revolving motion of the crank wheel into a reciprocating motion, which it transmits to the sickle.

7. Cutting Mechanism (Fig. 146).—The actual cutting of the grass is accomplished by two parts:

(*a*) The *moving sickle sections* (Fig. 146, *a*).

(*b*) The *stationary guard plate* (Fig. 146, *b*).

These two furnish the two parts of the shearing contact that accomplishes the cutting. There are many sections in the sickle, and many guard plates, but each set acts in the same manner.

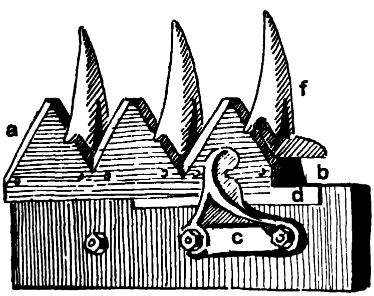


FIG. 146.—Detail of cutting mechanism

Both sides of each sickle section and both sides of each guard plate act as shears. On the outward stroke of the sickle, one side of the section cuts; on the return stroke, the opposite side cuts.

The sickle of a standard 5-ft. mower has twenty sections and twenty guard plates. This means that there are forty sets of shearing or cutting contacts. To keep all of these cutting properly, certain other parts are necessary.

(*c*) The *sickle clips* (Fig. 146, *c*) press down on the sections so that they make a close contract with the guard plate (Fig. 146, *b*) which is the under side of the shear. The necessity for this may be easily illustrated with a pair of shears that have loose blades.

(*d*) The *wearing plates* (Fig. 146, *d*) provide a runner or support for the under side of the sickle. They must be renewed frequently as they are subject to rapid wear. When worn they

allow the sickle to become loose or flop up and down. When this occurs the section and guard plate do not meet properly and the grass is torn loose rather than cut.

(*e*) The *guards* carry the guard plates as shown in Fig. 146, (*f* and *b*). One guard is provided for each section. The function of the guards is to direct the grass toward the cutting sections in such a manner that it may be cut to the best advantage. The long fingers of the guards support the grass while it is being cut, pick up tangled grass, and prevent the sections from striking obstructions in the field.

(*f*) The *cutter bar* is the heavy bar to which the guards are bolted and on which the sickle is carried (Fig. 146, *e*). It is tapered toward the outer end and strongly made to give the necessary rigidity.

(*g*) The *inner shoe* is the large shoe that supports the inner end of the cutter bar (Fig. 145, *b*). This acts as a runner for the cutter bar when the mower is in operation. It is provided with a removable sole (*c*) which is easily replaced when worn. The sole may be adjusted by means of a bolt at the rear of the shoe.

(*h*) The *outer shoe* is the smaller shoe that supports the outer end of the cutter bar (Fig. 147, *a*). This also has an adjustable sole. The pointed front end of the outer shoe acts as a divider, and separates the standing grass from that which is to be cut. This causes a clear, distinct cutting edge to be left.

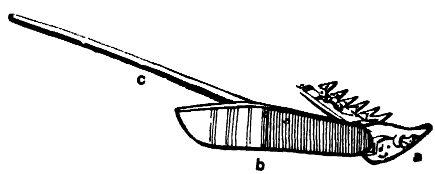


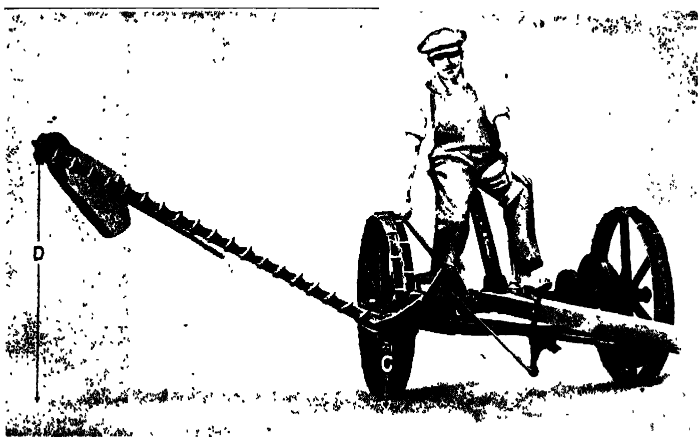
FIG. 147.—Outer shoe, grass board and grass stick.

(*i*) The *grass board* (Fig. 147, *b*) is bolted to the outer shoe. It is usually set so that it follows the contour of the ground and throws the grass over toward the center of the cutter bar. This is necessary in order to provide a clear space in which the horses may walk when cutting the next swath. It also makes raking up the hay much easier.

(*j*) The *grass stick* (Fig. 147, *c*) is bolted to the inside of the grass board. It assists the grass board in laying the cut grass in a well-piled row or swath. It is adjustable for high or low grass.

8. Levers.—Standard types of mowers are provided with three levers.

The large hand lever (Fig. 150) is called the lifting lever.



Courtesy of International Harvester Co.

FIG. 148.—Regular lift mower.

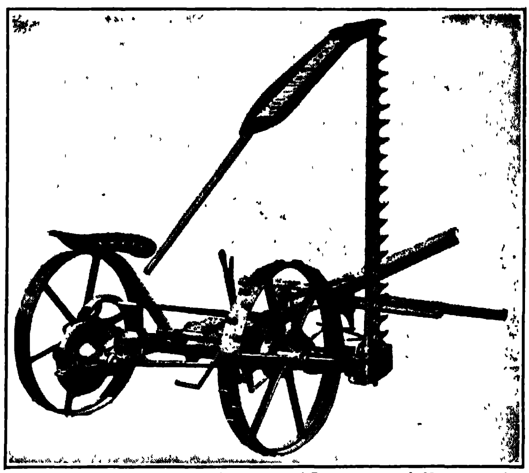
It raises the cutter bar high off the ground when the mower is not cutting. It may be suspended or locked in this position.

The action of the lifting lever is shown in Fig. 148. This illustration shows what is termed a "regular lift" mower. The maximum height to which the cutter bar can be raised by the lifting lever is here illustrated. The distance *C* is about 13 ins. and the distance *D* about 41 ins.

A "vertical-lift" mower is shown in Fig. 149. The cutter bar on this type may be raised to a vertical position with the lifting lever.

When the bar is being raised, the cutting mechanism is

automatically thrown out of gear. When the bar is lowered again the cutting mechanism is again started. Vertical-lift mowers are the better type for fields that have many stumps, trees, or other obstructions. As indicated in Fig. 149, the grass may be cut close up to the obstruction. The cutter bar is then quickly raised to a vertical position with the lifting lever and lowered again when the obstruction has been passed. With regular-lift mowers the cutter bar cannot be raised to a vertical position without the operator leaving the seat.



Courtesy of International Harvester Co.

FIG. 149.—Vertical lift mower.

The foot lever (Fig. 150, *b*) is also used to lift the cutter bar off the ground. It does not lift as high as the hand lever. The foot lever is used while the mower is in operation to lift the bar over stones or obstructions, or when turning corners. As there is no latch on the foot lever to lock the cutter bar in the raised position, the operator must hold it down with his foot to keep the bar in that position. Releasing the pressure allows the cutter bar to drop to the ground.

The lifting action of both the foot lever and the hand lever is affected by the tension of the lifting spring. This is adjustable and should be set so that the cutter bar rests lightly on the ground. The proper setting of the lifting spring greatly reduces the friction between the cutter bar and the ground, and this in turn lessens the draft of the mower.

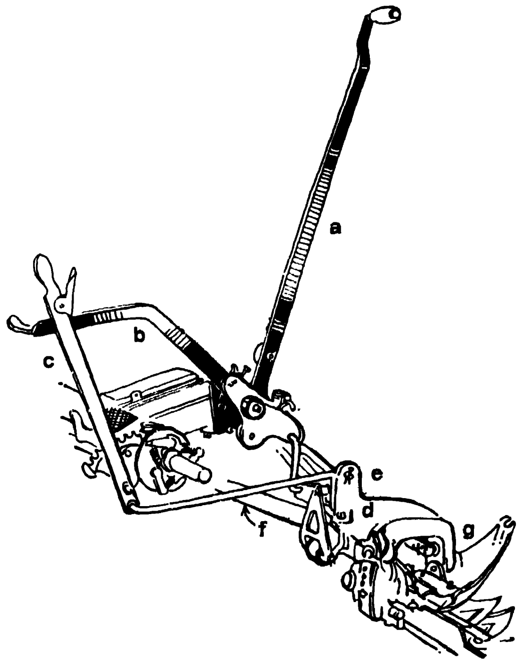


FIG. 150.—Levers used on a standard type of mower.

The tilting lever (Fig. 150, *c*) is used to regulate the angle between the cutter bar and the ground. It may be set so that the guard points are inclined upward, parallel with the ground, or inclined downward toward the ground. This setting determines how short the grass will be cut. Tilting the guard points downward, for instance, would cause the grass to be cut off

very near the ground. Under ordinary conditions, however, the cutter bar should be kept level, and the height of cut regulated by the adjustable soles under the inner and outer shoes.

9. Hinge, or Yoke (Fig. 150, *d*).—A large casting called the hinge, or yoke, is connected to the inner shoe by large pins. The tilting lever is connected to the hinge as shown in Fig. 150, *e*. The hand lifting lever and the foot lever are also connected to the hinge.

Two coupling bars, Figs. 150, *f* and *g*, connect the hinge to the mower frame. The rear bar (Fig. 150, *f*) is called the "push bar" as it pushes the cutter bar by means of its connection to the hinge. The length of the front coupling bar is adjustable. The purpose and proper method of adjusting it will be explained in Lab. Study No. 10.

10. Eveners.—Wooden eveners are used on horse-drawn mowers. They are carried on the under side of the pole by means of an iron draft bracket, which is bolted to the pole. A draw bar, which is connected between the draft iron and the hinge, applies the power directly to the cutter bar. The standard makes of mowers have both the draw bar and the push bar. The cutter bar, therefore, may be said to be pushed by the frame of the mower and pulled by the eveners.

LABORATORY STUDY NO. 9

To trace the transmission of power through the mower and determine grear ratios and speed of sickle.

Equipment Necessary.—A mower (new or used) complete with all parts.

Procedure.

1. Jack up the mower securely so that both rear wheels are off the floor.
2. Engage the clutch by means of the small clutch-shifting lever (Fig. 141, *d*).
3. Lower the sickle to the working position.
4. Turn one of the main wheels in the forward direction.

   (*a*) What causes the clicking noise heard in the opposite wheel?

5. Locate and name in order all the parts through which the power is transmitted from the main wheels to the sickle.
6. Turn the drive wheel slowly one complete revolution and count the number of revolutions made by the crank wheel.

   (*a*) If the mower is being drawn at the rate of 2 miles per hour, how many revolutions per minute does the crank wheel make?

   (*b*) Why is it so essential that the crank wheel and pitman box be well lubricated?

   (*c*) How far does the sickle travel for each revolution of the crank wheel?

   (*d*) How far does the sickle travel per minute when the mower is drawn at the rate of 2 miles per hour?

LABORATORY STUDY NO. 10

To " center " or " register " the sickle.

Equipment Necessary.—A complete mower.

Procedure.

1. Turn the crank wheel until the pitman is " on center " (at either extreme end of its stroke).

2. Observe the position of the sickle sections when the pitman is " on center." They should be exactly in the center of the guard. In this position the sickle is said to " center " or " register."

3. Adjust so that the sickle " registers " properly with the crank on either center.

In some mowers the pitman may be adjusted so as to get proper registering of the sickle. In others it is necessary to adjust the coupling bars (Fig. 150, *f* and *g*) for this purpose. The front coupling bar is usually threaded at one end so that it may be either lengthened or shortened as desired. The rear coupling bar (Fig. 150, *f*) may be adjusted by placing spacing washers on either side of the connection between the bar and the hinge. The effect of this adjustment is to move the hinge toward or away from the crank wheel, whichever is required to make the sickle register properly.

4. Study the movement and action of the sickle and determine why it is necessary that the sickle be made to register.

LABORATORY STUDY NO. 11

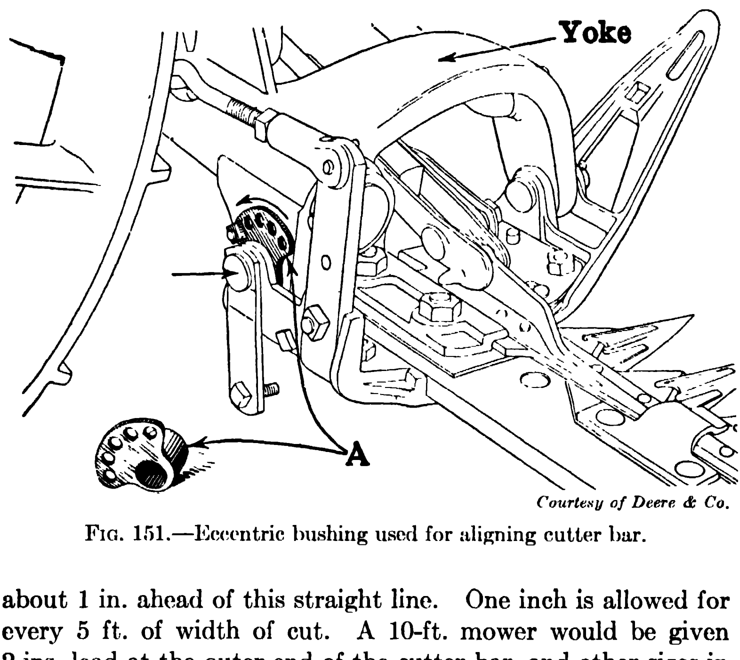
To align the cutter bar.

Equipment Necessary.—A complete mower.

Procedure.

1. Lower the cutter bar to the working position.

2. Stretch a string or use a straight metal rod to get a straight line through the center of the pitman, out to the end of the cutter bar. The outer end of the cutter bar should be



Courtesy of Deere & Co.

FIG. 151.—Eccentric bushing used for aligning cutter bar.

about 1 in. ahead of this straight line. One inch is allowed for every 5 ft. of width of cut. A 10-ft. mower would be given 2 ins. lead at the outer end of the cutter bar, and other sizes in proportion.

3. Adjust the cutter bar to secure the proper amount of lead at the outer end. In some mowers this is done by shortening the front coupling bar (Fig. 150, *g*). In other mowers a special

eccentric bushing is placed on the rear of the inner shoe, to care for this adjustment. (See Fig. 151, *A*.)

If this adjustment is wrong it greatly increases the draft of the mower. When the mower is in operation the pitmans and sickle should form a straight line. If the sickle lags back, it binds and the draft becomes very heavy.

The pressure of the grass and the ground forces the cutter bar back at the outer end when the mower is cutting. Hence the lead given the outer end results in the cutter bar being forced back into the true line when the machine is in operation.

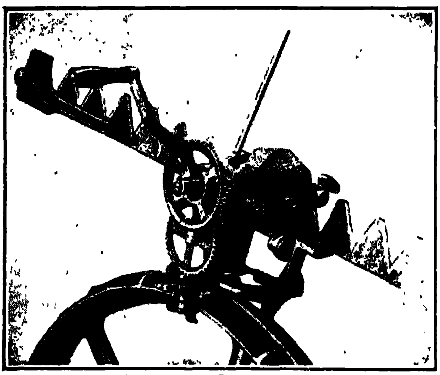
LABORATORY STUDY NO. 12

To sharpen the mower sickle and replace broken sickle sections.

Procedure.

1. Grind the sickle sections on the grindstone, being careful to preserve the original shape and bevel. A common error in grinding sections is to grind too much away from the point and not enough from the heel.

Note.—Special grinding wheels (Fig. 152), beveled for sickle grinding, may be secured from the manufacturer of the mower. Better work can be done with these than with the grindstone. One side of two different sections is ground at the same time. The work can be done accurately and rapidly.



Courtesy of International Harvester Co.

FIG. 152.—Sickle grinding wheel.

2. Remove the broken sections from the sickle. The most satisfactory method of doing this is to set the edge of the sickle bar on a block of iron, with the sections extending downward. Strike the back of the section a heavy blow at a point directly above the rivet. This will shear off the rivets and the section will drop off. The rivets may then be easily punched out of the holes in the sickle bar.[1]

3. Put the new sickle sections in place and rivet them securely. Be sure to use rivets of the proper length and thickness. They should be large enough to fill completely the holes in the section and in the sickle bar.

[1] *See* Extension Bulletin, No. 155, "Sharpening Farm Tools," by L. M. Roehl, Cornell University, Ithaca, N. Y.

Job No. 23

TO OVERHAUL AND REPAIR A MOWER

Operations Necessary to Perform the Job.

1. Inspect countershaft bearings and replace if necessary.
2. Mesh bevel gear and pinion to proper depth.
3. Inspect crankshaft bearings and replace if necessary.
4. Examine spur gear and pinion.
5. Remove wheels and clean roller bearings.
6. Replace pawls and pawl springs.
7. Inspect wrist pin and replace it if worn.
8. Replace pitman box and pitman straps.
9. Replace sickle head if necessary.
10. Replace worn guard plates, wearing plates, sickle clips, and sickle-head caps as required.
11. Align guards. Replace broken guards.
12. Align cutter bar.
13. Register sickle.
14. Remove and sharpen sickle.
15. Paint all parts as instructed below (page 213).

Description of Operations.

1. Test the bearings of the countershaft and renew them if badly worn. A loose countershaft causes rapid wear of the bevel gears and may even cause these gears to slip past each other, thus causing the sickle to stop and grass to be left uncut.

2. Adjust the nut on the end of the countershaft (Fig. 141, *g*) to take up the wear in the bevel gears and make them mesh properly.

3. Test the bearings of the crankshaft and replace with new bearings if possible. Worn crank-shaft bearings will allow the bevel gears to wear fast, and may even result in their getting out of mesh and skipping. They may also prevent the sickle from registering properly, and cause noisy and inefficient operation.

4. Examine the main spur gear (Fig. 140, *b*) and the main spur gear pinion (Fig. 140, *d*). Replace them if the teeth are badly worn. Sometimes the teeth of these gears become worn almost to a point. Then, when the mower is used in heavy grass, the teeth of the two gears slip past each other and the sickle stops.

5. Jack up the mower and remove both drive wheels. Remove the roller bearings and wash them out with kerosene.

6. Put in a complete new set of pawls and pawl springs. Worn pawls or weak springs may cause lost motion in the mower sickle. It is best to replace the pawls each time the mower is overhauled.

7. Examine the wrist pin (Fig. 144, *b*). This should be replaced with a new one if it is worn out of round. To do this, the head of the wrist pin, where it is riveted on the back of the crank wheel, must be filed or chiseled off. The wrist pin can then be punched out of the crank wheel and a new one inserted.

8. Test the pitman box, pitman pivot straps, front and rear pitman straps. These are subjected to a great deal of wear and probably will need to be replaced on each mower overhauled.

9. Test the connection of the pitman straps on the ball of the sickle head (Fig. 145). This ball is frequently worn so that it also should be replaced to get a good tight connection. Looseness at this joint will cause very rapid wear.

10. Examine the guard plates carefully, and replace any that are worn or broken. These are held in place in the guard by one rivet. File off the end of the rivet and punch it out, and the guard plate will loosen. It is, of course, first necessary to loosen the guard bolt and take the guard off the cutter bar.

11. Replace the wearing plates (Fig. 146, *d*) and the sickle clips (Fig. 146, *c*). If the sickle clips are not too badly worn, they may be bent downward by striking them with a hammer, so that they will hold the sickle down properly against the wearing plates. A slight clearance (about $\frac{1}{100}$ in.) is desirable between the sickle and the sickle clips.

12. Test the sickle-head caps (on inner shoe) for wear, in the same manner as the sickle clips. Replace them if necessary.

13. Examine the swath board and grass stick. Tighten the connection between the swath board and the outer shoe.

14. Wash all parts thoroughly with kerosene to remove grease and dirt. Be particularly careful to clean out the spur gear and the bevel-gear housings.

15. Examine the guards. Straighten any that are bent out of proper alignment. (Cardboard shims between the guard and cutter bar are sometimes useful for bringing guards into alignment.) Replace broken guards.

16. Align the cutter bar as described in Laboratory Study No. 11, page 208.

17. Register the sickle as described in Laboratory Study No. 10, page 207.

18. Sharpen the mower sickles and replace broken sections as described in Laboratory Study No. 12, page 210.

19. Paint all parts of the mower, except the sickles, gear teeth, lever detents, etc. (where paint would hinder proper operation).

20. Remove the sickles and cover them with a coating of thick oil or grease. Store the sickles in a safe plce.

Job No. 24

TO OPERATE A MOWER

Operations Necessary to Perform the Job.

1. Lubricate all moving parts.
2. Adjust height of pole and level cutter bar.
3. Operate mower idle for a few minutes' test run.
4. Start mowing by traveling around outside edges of field.
5. Regulate height of cut and operate levers.
6. Adjust grass board and grass stick.

Description of Operations.

1. Oil all parts thoroughly. Clean out all oil holes with the sharp wire. Clean out the casings or shields covering the gears.

Locate and oil the following parts. These should be oiled every half hour while the mower is running.

(*a*) Crankshaft bearings (2).
(*b*) Countershaft bearings (2).
(*c*) Pitman bearings (2), one at each end of the pitman.

Locate and oil the following parts. These should be oiled twice a day when the mower is in operation.

(*a*) Main axle bearings.
(*b*) Main wheel hubs.
(*c*) Clutch-shifting parts.
(*d*) Inner-shoe pins.
(*e*) Joints of lifting mechanism.
(*f*) Levers and pivots.

2. Adjust the height of the tongue. The front end of the tongue must be carried about 30 to 32 ins. above the ground on horse-drawn mowers. This distance may be adjusted by the neckyoke straps. This is an important adjustment. If it is properly made the cutter bar sets level and square on the

shoes, and the various parts of the frame are at the correct working angle.

3. Operate the mower idle. Before beginning to cut, the mower, especially if new, should be run idle for a short time. This will enable the operator to know if all parts are working properly.

With a new mower it is well to lubricate all parts with kerosene and then run the machine idle. This will cut any paint that may have worked into the bearings and make the mower run much easier. After it has been run idle a few minutes, the mower should be thoroughly lubricated with good oil.

4. Start mowing around the outer edges of the field. Mowing is done by driving the machine around the field, not back and forth across the field as is done with the plow or harrow. The field is started at one corner and the mower is driven clear around, following the boundary at each edge of the field. Each succeeding swath is nearer the center of the field.

It is sometimes necessary to drive the horses or the tractor through the standing grass when making the first round. The grass that is thus left standing may be cut later, by driving around the field in the opposite direction.

Raise the cutter bar with the foot lever at the corners. The mower is run straight down one edge of the field until the cutter bar completes its swath. It is backed so that the sickle will enter full width into the grass of the next edge of the field. Then the foot lever is released and the cutter bar dropped again.

Beginners will experience some difficulty in turning at the corners of the field. The swath cut at the corner must be the same width as that in any other part of the field.

The clutch is engaged by a small foot pedal located near the driver's seat. This must be done before driving the mower into the grass. The sickle should always be moving before the mower enters the grass, otherwise it may become clogged up.

5. Regulate the height of cut and operate the levers as required. The soles of the inner and outer shoes are raised or

lowered to regulate the height of cut. Both soles should be adjusted so that the cutter bar will be level.

The cutter bar may be tilted forward for cutting very short grass. This should be done only on fields that are known to be free from obstructions, otherwise the knife and guards may be broken or damaged. For this reason it is desirable to have the guards tilted upward when working on rough ground.

The foot lever is used to raise the cutter bar a short distance above the ground. When passing over stones, roots, or other obstacles that do not project high above the ground, the foot lever alone is necessary.

The large lifting lever is used to raise the cutter bar high above the ground. This is necessary in order to pass over high obstacles. Raising the bar with this lever disengages the clutch. The action of the foot lever alone does not disengage the clutch. The lifting spring should be adjusted so that the bar can be easily lifted with either lever.

6. Adjust the grass board and stick. The grass board is usually left slightly loose so that its under side follows the contour of the ground. The grass stick should be set so that it lays the cut grass well to the left of the outer end of the cutter bar. This allows the two horses or the tractor to straddle the cut swath the next time around. The rear end of the stick should be raised for cutting tall grass and lowered for cutting short grass.

FIELD TROUBLES

The mower cannot be operated to advantage when the grass is too wet. The wet grass has a tendency to clog the sickle and also may cause the drive wheels to slip.

Under normal conditions, however, the mower gives very little trouble. The various troubles that do occur are nearly always caused by a wrong adjustment or worn parts.

The more common troubles are listed below, with their causes and remedies.

1. Sickle Becomes Clogged or Stops and Drive Wheels Slide.—This may be caused by any one of the following conditions:

(*a*) Some obstruction may be stuck in the sickle.

(*b*) Grass may be wedged in between the sickle and the guard plate.

(*c*) The guards may be out of alignment (bent due to striking obstruction).

(*d*) The sickle may be clogged owing to the operator's starting the mower in heavy grass. The sickle should be in motion before entering the grass.

(*e*) The pawls may be worn. This causes lost motion, which allows the sickle to be idle for an instant when the mower is started. The grass wedges in the stationary sickle and clogs it.

The above troubles may be remedied by replacing worn parts, correcting the alignment of the guards, or adjusting the sickle clips properly.

2. Pitman Box Heats and Knocks.—This is usually caused by a worn bearing. The large space thus left between the wrist pin and the bearing allows all the lubrication to leak out, and heating results.

The pitman box in this case should be replaced.

3. Cutter Bar Jumps or Rises Frequently.—This is caused by the lifting spring being too tight. Loosen the spring so that the bar rests more heavily on the ground.

4. Sickle Does Not Start with Drive Wheels.—(Wheels turn part of a revolution before sickle begins to move.) This condition should be remedied at once as it will give constant annoyance.

It may be caused by any one of the following conditions:

(*a*) Worn pawls, ratchets, or pawl springs.

(*b*) Worn bearings on the countershaft or crankshaft.

(*c*) Worn gears on the countershaft or crankshaft.

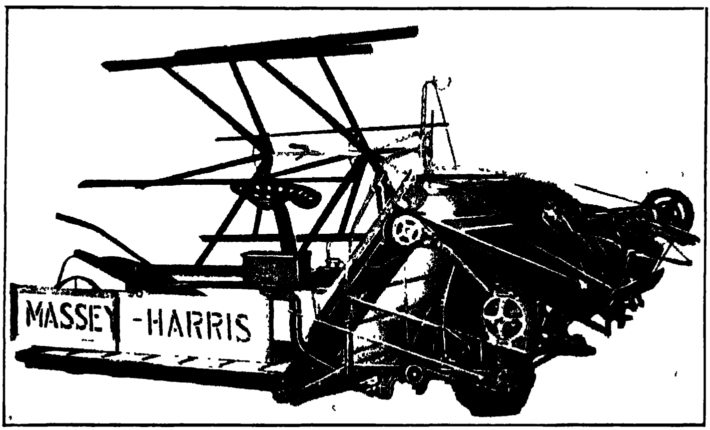
(*d*) Worn clutch.

(*e*) Connection between pitman and sickle head worn.

CHAPTER VII

GRAIN BINDERS

The grain binder is one of the most intricate of all farm implements. Considering the variety of operations which it performs, its adaptability to different field conditions and the rapid rate at which the work is accomplished, the grain binder



Courtesy of Massey-Harris Harvester Co., Inc.

FIG. 153.—Grain binder.

presents an excellent example of engineering ability and manufacturing efficiency.

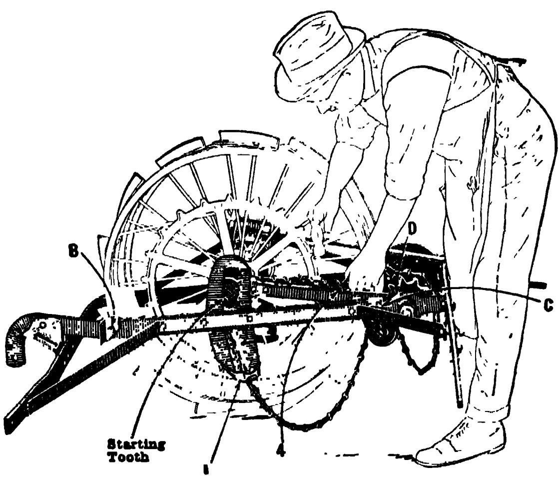
The harvesting operation accomplished by the grain binder includes cutting the standing grain, binding the cut grain into compact bundles, and dropping the bundles in rows (called windrows) across the field.

The accomplishment of this three-fold function requires many mechanical adjustments on the binder. These will be discussed in detail in this chapter. Some of the varying conditions necessitating a wide range of adjustments are as follows:

1. Topography of the field: hills, gullies, etc.
2. Very short or very tall grain.
3. Lodged or tangled grain.
4. Heavy or light grain.
5. Green, ripe, or over-ripe grain.

CONSTRUCTION AND PRINCIPAL PARTS

1. Main Frame (Fig. 154).—The main frame is made up of flat or angle steel bars, which are riveted together and well



Courtesy of Deere & Co.

FIG. 154.—Assembling main wheel, frame and main chain.

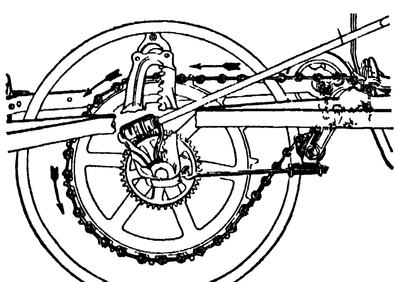
braced. They form a rectangle with the inner ends projecting. These ends are bolted to the binder platform.

Two brackets are bolted at the center of the main frame. These center the main wheel and serve as hangers to place the weight of the frame upon the main wheel (Fig. 154, *1*).

Bearings for two shafts are carried in the main frame. These shafts are the countershaft and the crankshaft. Two roller bearings are provided for the countershaft and two roller bearings for the crankshaft. The two countershaft bearings and one of the crankshaft bearings are shown in Fig. 156.

A bracket for connecting the tongue is bolted to the front of the frame (Fig. 154).

2. Main Wheel (Fig. 154).—The main wheel carries the greater part of the weight of the machine. It also acts as a drive wheel and furnishes power for all of the moving parts. The rim of the wheel carries lugs so that good traction may be secured. The main wheel is mounted on a short axle which is carried on two roller bearings. A removable sleeve slips through the center of the wheel hub and revolves on the roller bearings. A small pinion is keyed to each end of the main-wheel axle. This fixes the axle in the brackets. The axle is stationary and the wheel revolves on it. By means of a raising-crank worm and worm gear (Fig. 155) the axle may be raised or lowered in the brackets. This regulates the height at which the grain is cut.



Courtesy of International Harvester Co.

Fig. 155.—Main wheel, main chain and raising crank.

A large sprocket is bolted to the hub of the wheel. The driving power for all the working parts is transmitted by this main sprocket.

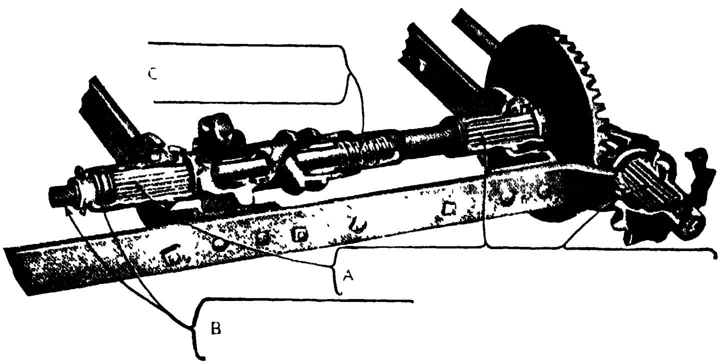
3. Main Chain (Fig. 155).— A large chain transmits the power from the main-wheel sprocket to the clutch sprocket which is carried on the countershaft. A tightener is provided to keep the chain at proper tension.

4. Transmission of Power to Sickle.—The various parts which transmit the power to the sickle are quite similar in con-

struction and function to those used for this purpose in mowers. Hence the description will not be repeated here. The parts referred to are as follows:

(*a*) *Countershaft and Bearings* (Fig. 156).

(*b*) *Clutch and Clutch Sprocket* (Figs. 154, *D* and 156, *C*). The clutch and sprocket are located on the countershaft. A clutch-shifting fork is connected to the clutch by means of a rod located near the operator's seat. Turning this rod slides the clutch along the shaft and allows the notches to come out of engagement. The clutch sprocket revolves freely upon the



Courtesy of Deere & Co.

FIG. 156.—Countershaft and bevel gears

countershaft and does not drive it unless the clutch is engaged. A large coil spring holds the clutch in engagement.

An adjustment is provided on the countershaft for taking up wear in the bevel gears (Fig. 156, *B*).

(*c*) *Bevel Pinion and Bevel Gear* (Fig. 156).—As in the mower, these gears change the direction of the motion, the crankshaft being placed at a right angle with the countershaft. The large bevel gear is keyed to the countershaft and the small bevel pinion is keyed to the crankshaft. These gears are protected with a shield which is not shown in the illustration.

The crankshaft sprocket is keyed to the rear of the crank-

shaft. This is used to transmit power to drive the various parts of the binding mechanism and the platform and elevator canvases.

(*d*) *Crank and Wrist Pin.*—The crank (Fig. 157, *a*) is keyed to the front end of the crankshaft. It carries the wrist pin (Fig. 157, *b*) to which the pitman (Fig. 157, *c*) is attached. A crank wheel, similar to that used in mowers, is used on some makes of grain binders.

(*e*) *Pitman.*—The pitman (Fig. 157, *c*) may be made of wood or steel, wooden pitmans being the more commonly used. Wood is light and resilient. The pitman is held in place on the wrist pin by a latch or nut. It may be easily removed when it is necessary to change the knife.

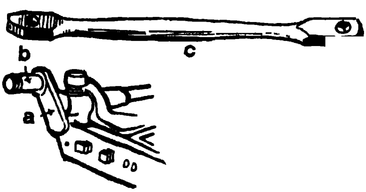
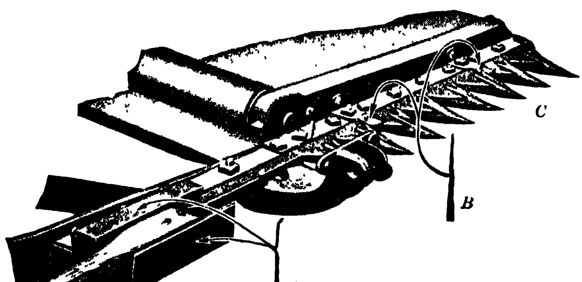


FIG. 157.—Crank wrist pin and pitman.

The opposite end of the pitman slips over the stud in the end of the sickle head and is held in place by a steel guide (Fig. 158, *A*).



Courtesy of Deere & Co.

FIG. 158.—Connection of pitman to sickle.

5. Cutter Bar (Fig. 158, *C*).—The construction of the cutter bar is similar to that of the corresponding part of the mower. The guards, guard plates, sickle clips, and wearing plates are

attached in the same manner and have the same functions as like parts of the mower.

The cutter bar of the binder, however, does not drag on the ground. The weight is borne on the wheels. There is no tendency, therefore, for the outer end of the cutter bar to lag behind, hence no provision for the alignment of the cutter bar is necessary.

The construction of the knife or sickle, guards, and cutter bar of a standard type of binder is illustrated in Fig. 158. The bar itself is made of heavy-stock Z-bar angle steel. The guards are bolted to the cutter bar. They are spaced 3 ins. apart, as in mowers. A 7-ft. binder, therefore, has twenty-eight guards. The sickle sections are held down against the guard plates by the knife holder (Fig. 158, *B*).

The shape of the sections of the binder sickle is somewhat different from that of those in the mower. The regular binder section is rough or serrated. This type of section is used for cutting all kinds of grain, where the straw is always fairly dry. Smooth sections may be obtained for binder sickles in case it is necessary to use the binder for cutting grass crops.

Smooth guard plates are used in connection with the rough or serrated section. This combination gives the best results for cutting grain.

The travel of the sickle is twice as far as in the mower. No adjustment is provided for centering or registering it.

6. Grain Wheel (Fig. 159, *a*).—The small wheel is called the grain wheel as it runs at the side of the swath nearest the uncut grain. It supports and is attached to the outer end of the platform. The axle for the grain wheel is cast integral with the axle slide (Fig. 159, *b*). This slide may be raised or lowered by means of the crank (Fig. 159, *c*), thus changing the height at which the grain is cut. The adjustment of the height of the outer end of the platform is made by the grain wheel. The height of the inner end of the platform may be changed by raising the main wheel. These adjustments must be so made that the grain is cut the same length at both ends of the platform. This usually

means that the platform will be level, but on side hills one end of the platform may be lower than the other. To do even,

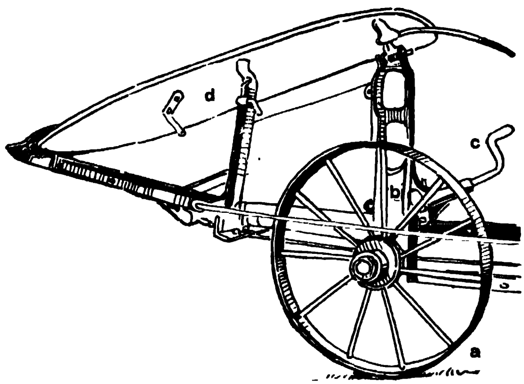


FIG. 159.—Grain wheel and outside divider.

uniform cutting, the platform must be set so as to conform to the slope of the ground.

The grain wheel revolves on a roller bearing, which is lubricated by means of an oil tube in the hub of the wheel.

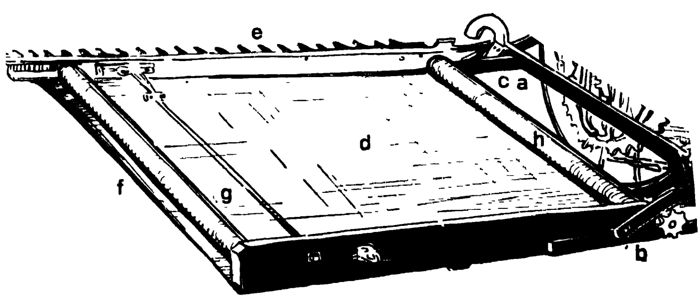


FIG. 160.—Platform and platform rollers.

7. Platform.—Figure 160, *d* shows the platform with the platform rollers in place. The cutter bar (Fig. 160, *e*) is attached to the front of the platform. As the grain is cut by the sickle

it falls on the moving platform apron (Fig. 162, *a*) which conducts it to the elevators (Fig. 162, *b* and *c*).

To prevent the grain (especially very tall grain) from being carried or blown over the rear of the platform, the platform deck (Fig. 161, *a*) and the wind break or back curtain (Fig. 161, *b*) are used. Both of these are adjustable. They practically enclose the rear of the platform.

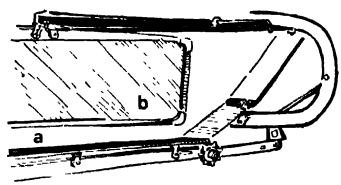


FIG. 161.—Platform deck and back curtain

Figure 160 gives a view of the platform without the apron in place. Note the two platform rollers *f* and *h*. The inner roller is driven by the sprocket and this roller drives the canvas apron. The outside roller is a carrier or " idler " roller only, that is, it does not drive but only carries the canvas apron.

The outside roller is provided with a canvas tightener (Fig. 160, *g*). If the aprons are not tight enough the rollers will slip inside of them and the aprons will not move. As it is difficult to draw the straps on the aprons tight enough, some form of canvas tightener is usually provided for all the aprons. The aprons must be kept tight while the binder is in operation. If the binder is left over night or for a few hours with the aprons on, the canvas tightener for each apron should be released.

The bottom of the platform is made of sheet steel, which is carried on three or more angle-iron cross sills.

8. Elevators and Rollers (Fig. 162).—The elevators with their aprons receive the grain from the platform apron and carry it upward or "elevate" it, to the deck (Fig. 162, *d*) where it is bound into bundles, as will be described later.

Figure 162 shows the placement of the rollers, the direction of travel of the elevator aprons, and the course of the grain as it travels upward between the upper and lower elevators. Figure 162, *e* shows the lower, and Fig. 162, *f* the upper roller, of the lower elevator. Figure 162, *g* is the lower, and Fig. 162, *h*

the upper roller of the upper elevator. The aprons travel in the directions indicated by the arrows.

The lower rollers of both elevators are idle rollers (not driven). They are pivoted to the elevator guides so that the lower rollers may be raised. This shortens the distance between the lower and upper rollers of the elevator. These pivoted bushings, therefore, are used as canvas tighteners. The canvas straps are drawn tight with the rollers in the loose position. Then the operator can press the rollers down firmly with his foot and they will lock in the downward position and tighten the canvases.

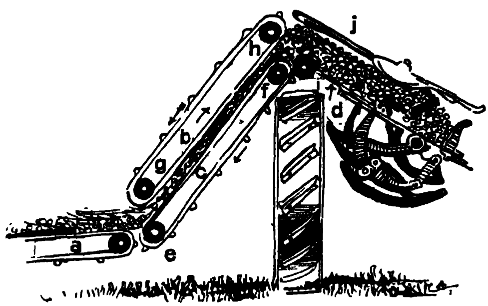


FIG. 162.—Elevation of grain from platform to binder deck.

The rollers at the upper ends of the elevators are both driven rollers. The upper roller of the lower elevator is the main-drive roller. It is driven by the sprocket (Fig. 163, *c*). The opposite end of this roller is geared to the roller above it so that the two turn together. This gearing, which is at the front of the binder, is shown in Fig. 167.

The upper elevator is usually a floating one. If the grain is very heavy the upper elevator will be forced away from the lower one so as to allow more room between them for the passage of grain.

An additional roller, called the "deck roller," is placed as shown in Fig. 162, *i*. This helps to deliver the grain to the deck evenly. It is driven by gears from the main-drive roller. An intermediate gear is used so that the direction of rotation of the deck roller will be the same as that of the main-drive roller.

9. Apron Chain (Fig. 163).—One long chain, of about one hundred links, drives both elevator aprons and the platform apron. The driving power for this chain is taken from the crankshaft sprocket (Fig. 163, *a*). The chain then passes over

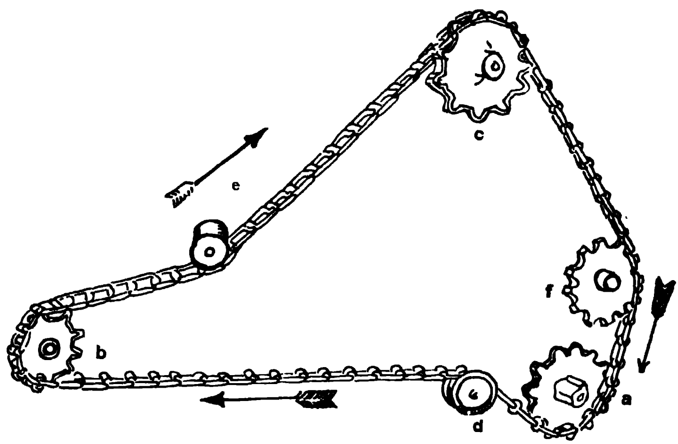


FIG. 163.—Apron chain.

the chain tightener (Fig. 163, *d*) down to the platform roller sprocket (Fig. 163, *b*), up and under the wooden chain tightener shown at Fig. 163, *e*, to the main-drive roller sprocket (Fig. 163, *c*). Then the chain passes downward over the binder-driving sprocket (Fig. 163, *f*) and returns to the crankshaft sprocket. The arrows show the direction in which the chain travels. The proper method of putting on the chain is shown in the accompanying illustration. The hooks of the chain should point forward. The curved back of the chain links should be next to the sprockets (Fig. 164).

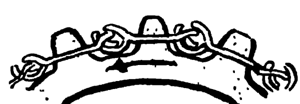


FIG. 164.—Proper method of assembling chain on drive sprocket.

10. Reel (Fig. 165).—The function of the reel is to bend the

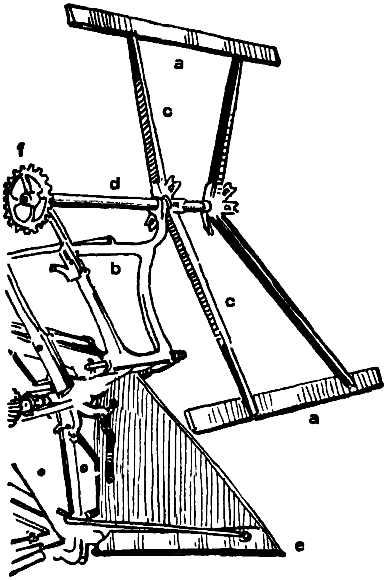
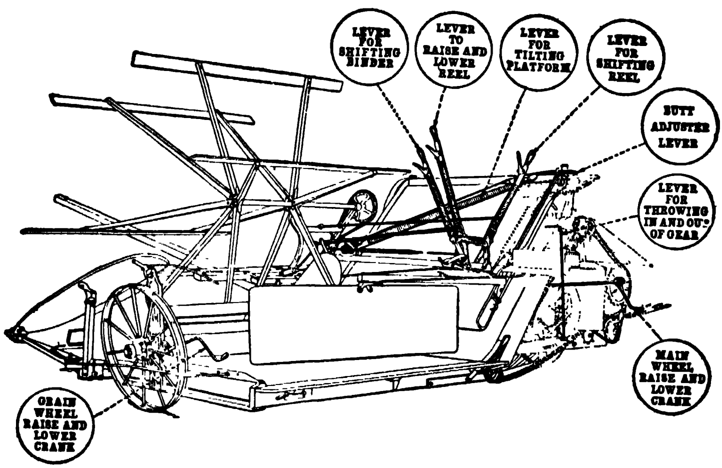


Fig. 165.—Reel and inside divider.

standing grain toward the sickle, and hold it against the sickle until after it has been cut.

Two of the levers, which are shown mounted in Fig. 166, are for adjusting the reel for various field conditions. One of these levers raises and lowers the reel, and the other tilts it forward or backward. The reel should be so adjusted that the slats (Fig. 165, *a*) strike the standing grain just below the head. They should not leave the grain until after it is cut. The levers are connected by rods to the reel



Courtesy of International Harvester Co.

Fig. 166.—Levers used on a standard type of grain binder.

frame (Fig. 165, *b*). The placement and purpose of all the levers of a standard type of binder are illustrated in Fig. 166.

The reel slats and reel arms (Fig. 165, *a* and *c*) are bolted to the reel shaft (Fig. 165, *d*). Six reel slats are commonly used. In binders of 7-ft. cut or more, the outside end of the reel shaft is supported by a standard. This standard is called the "outside reel support" as it is attached to the outer end of the platform. Figure 178 shows the location of the "outside reel support."

The reel slats reach from the inside divider to the outside divider (Fig. 159, *d*). Several holes are provided for attaching the slat to the arm so that proper adjustment may be made to prevent the slat ends from striking against either divider.

Power for driving the reel is taken from the front end of the main-drive roller and is transmitted through the spur gears (Fig. 167, *a*) to the bevel gears (Figs. 167, *b* and *c*). A combination bevel gear and sprocket (Fig. 167, *c*) transmits the power to the reel-driving sprocket shown in Fig. 165, *f*.

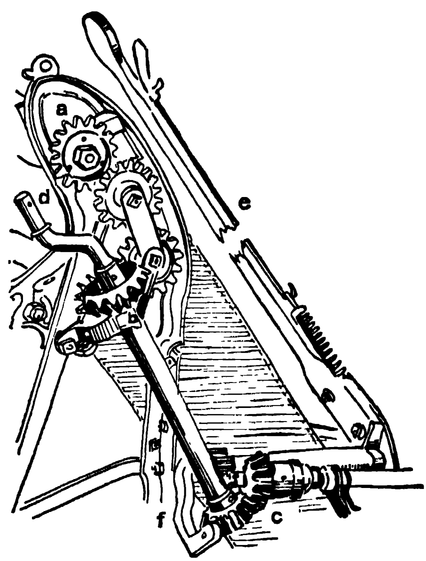


Fig. 167.—Reel driving parts.

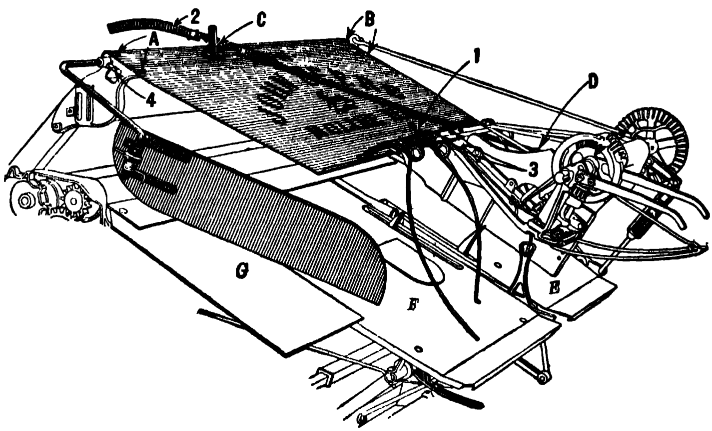
11. Inside Divider (Fig. 165, *e*).—The inside divider is made of sheet iron and is braced from the main frame as illustrated. Its function is to gather and direct the grain, at the inner edge of the swath, toward the sickle.

12. Outside Divider (Fig. 159, *d*).—The outside divider gathers and directs the grain toward the sickle at the outer edge of

the swath. It leaves a clear and distinct edge of uncut grain. The long, pointed front of the divider helps to pick up lodged or tangled grain and clears a track for the grain wheel.

The divider is bolted to the outer edge of the platform is three places, front, center, and rear.

13. Binder Deck (Fig. 168).—The cut grain is delivered by the elevator aprons and the deck roller to the deck. Here the loose grain is packed together and bound into compact bundles.



Courtesy of Deere & Co.

FIG. 168.—Binder deck, deflector and deck wind board.

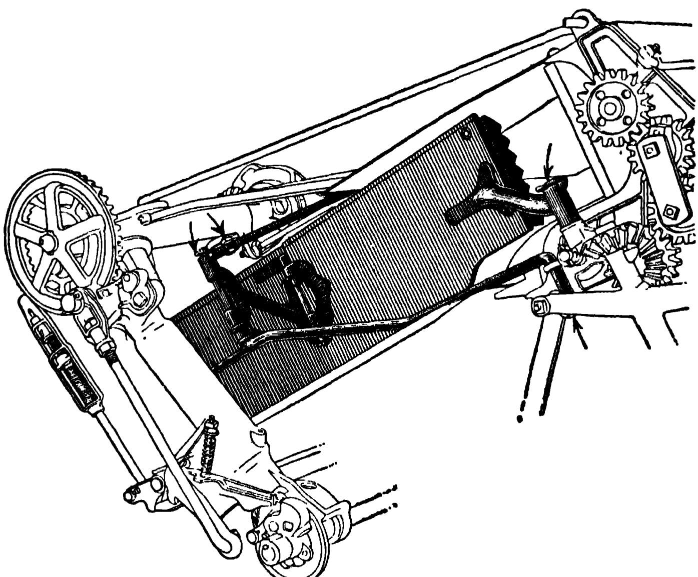
While this operation is being performed the grain is prevented from slipping down the inclined deck by means of the retarding springs and the trip hook (Fig. 168, *E*).

The deck is made of wood or steel. A center section is hinged so as to give access to the parts below it for lubrication and adjustment (Fig. 168, *F*).

The rear of the deck is enclosed by a small board, called the deck windboard (Fig. 168, *G*). This may be folded down to allow more space when long straw is being cut (Fig. 153). The deck wind board is attached as indicated at 4. The deflector is attached at *A* and *B*, Fig. 168. The sheet-iron

deflector keeps the cut grain down on the deck and prevents it from being blown out (Figs. 168 and 162, *j*).

14. Adjuster, or Butter (Fig. 169).—The adjuster is located at the front end of the binder deck. It is fastened by cotter pins at the points indicated by the arrows. The function of the adjuster is to keep the straws even at the butt end so that a



Courtesy of Deere & Co.

FIG. 169.—Adjuster or Butter.

well-shaped bundle may be secured. This process of evening up the straws at the butt gives rise to the term "butter." The crank shown in Fig. 167, *d*, drives the adjuster, or butter. The position of the adjuster may be regulated for long or short grain by means of a long shifting rod, which passes over the deflector to a point near the operator's seat (Fig. 168, *2*).

The inside of the adjuster is faced with triangular lugs, which aid in shaping the butts of the bundles.

15. Binder Attachment (Fig. 170).—The various parts that pack the straw into bundles, tie the bundles, and discharge them are considered as a unit, which is called the "binder attachment."

The binder attachment is mounted on the main frame. This whole unit may be moved forward or backward on the frame by means of the binder-shifting lever. This adjustment

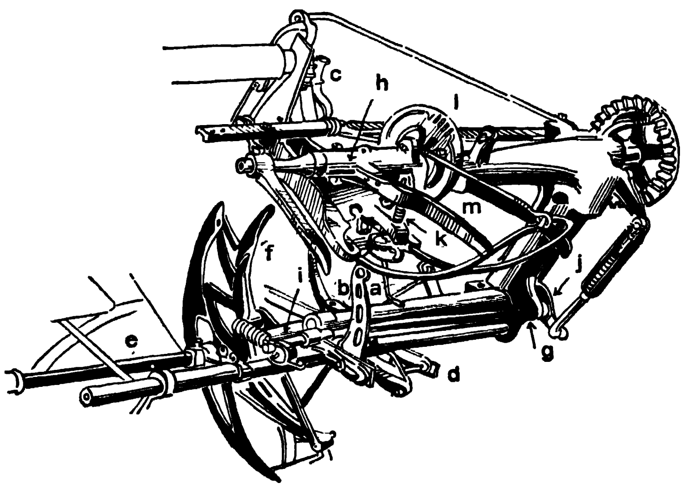


FIG. 170.—Binder attachment.

is necessary in order that the bundle may always be tied near the middle, regardless of the length of the straw.

(*a*) *Binder Drive.*—Figure 170, *c*, shows the means by which the binder attachment is driven. A square driving shaft transmits the power from the binder-driving sprocket to the packer crank.

(*b*) *Packers and Packer Crank* (Fig. 170, *f*).—The two arms or forks shown in the illustration are called packers. The upper ends of the packers project through slots in the deck. The motion of the packers presses the grain on the deck down

against the trip hook and packs it into a firm, compact bundle (Fig. 172).

The packer shaft extends to the front end of the binder. It is, in effect, an extension of the square drive shaft shown in Fig. 170, *e*. It transmits the driving power to the forward end of the binder attachment.

(*c*) *Binder Attachment Shafts*.—There are three shafts in the binder attachment in addition to the packer shaft mentioned above. These are as follows:

1. Needle shaft (Fig. 170, *i*).
2. Knotter shaft (Fig. 170, *h*).
3. Compressor shaft (Fig. 170, *g*).

None of these three shafts turns steadily; they move only when a bundle is being tied and discharged. At this time the knotter shaft revolves, but the compressor shaft merely rocks backward a few degrees. This slight motion unlatches the trip stop (Fig. 170, *j*). The knotter shaft and the needle shaft are in motion only while the trip stop is unlatched.

The knotter shaft and needle shaft are enclosed in the frame of the binder attachment. The location of the needle shaft is indicated by the arrow in Fig. 170, *i*, and the location of the knotter shaft by the arrow in Fig. 170, *h*.

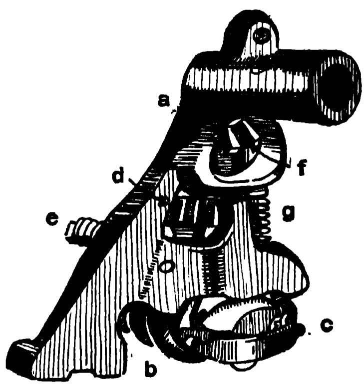


FIG. 171.—Principal parts of a standard type of knotter.

(*d*) *Knotter* (Fig. 171).—The knotter is carried at about the center of the binder attachment. It is mounted above the binder deck as indicated by the arrow in Fig. 170, *K*. The knotter ties a knot in the band of twine, which is drawn around the bundle by the needle. After this knot is tied, a small knife, contained within the knotter,

cuts the twine so that the bundle may be discharged. (See Fig. 172.)

There are three principal working parts in the knotter; as follows:

1. Knotter hook (Fig. 171, *b*).
2. Twine-holding disk (Fig. 171, *c*).
3. Twine knife.

The tension of the movable hook or bill may be adjusted by the spring and set screw shown in Fig. 171, *e*. The method of making the correct adjustment is discussed on page 250.

The tension of the twine-holding disk is regulated by the set screw and spring shown in Fig. 171, *g*. (See directions for making correct adjustment, page 249 and 250.)

The twine knife cuts the twine after the bundle has been tied. It must be kept sharp. This is best accomplished with an oil stone.

In order that the student may clearly understand the action of the knotter and all other parts of the binding attachment, a special study should be made of these parts. (See Laboratory Study No. 14, page 242.)

The moving parts of the knotter are driven from the knotter cam gear (Fig. 172, *b*). This cam is keyed to the knotter shaft. The small pinion (Fig. 171, *d*) drives the knotter hook (Fig. 171, *b*), which is the part that actually ties the knot. The small pinion shown in Fig. 171, *f* drives the twine-holding disk. Both of these pinions are driven by the knotter cam gear (Fig. 172, *b*).

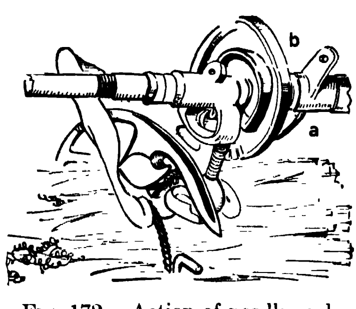
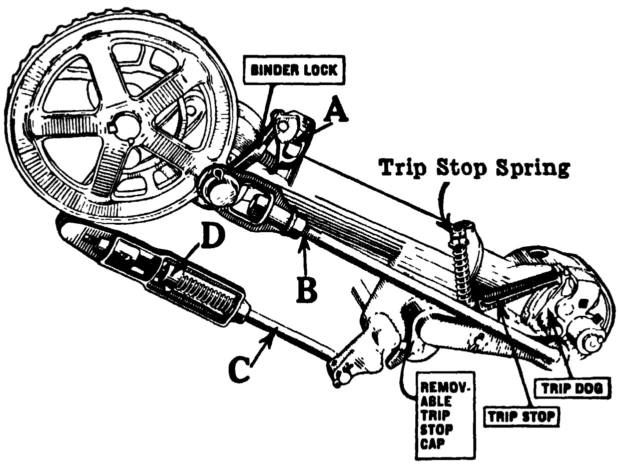


Fig. 172.—Action of needle and knotter.

(*e*) *Discharge Arms.* — The discharge arms are mounted on the inner end of the knotter shaft (Fig. 170, *m*). When the bundle is of the proper size

and sufficiently compressed, these arms revolve and throw it down off the binder deck on to the bundle carrier.

(*f*) *Trip Hook and Compressor Shaft.*—The loose grain is packed against the trip hook (Fig. 170, *b*) by the packers. As it accumulates, the pressure against the trip hook increases. When the proper amount of grain for a bundle has been accumulated, the pressure against the trip hook forces it back. This rocks back the compressor shaft and the trip stop is



Courtesy of Deere & Co.

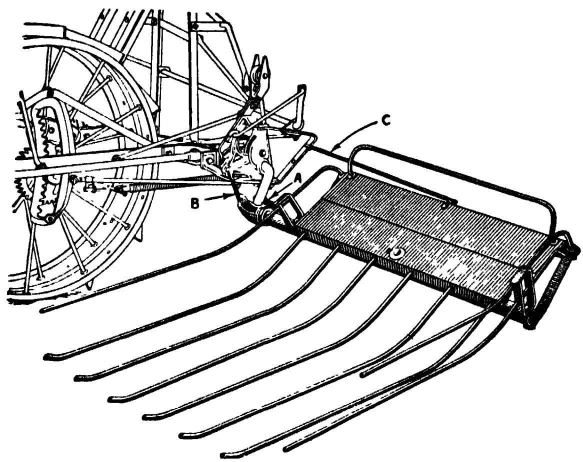
FIG. 173.—Trip stop, compressor spring and needle pitman.

unlatched (Fig. 173), whereupon the needle shaft and knotter shaft come into action. (When the trip stop is latched, both of these are idle.) The needle moves forward and upward, through a slot in the deck. The needle point carries the twine over the knotter hook and into the twine-holding disk, thus wrapping it around the bundle of grain (Fig. 172). At this point in the revolution of the knotter shaft, the gear teeth on the knotter cam come into mesh with the two pinions (Figs. 171, *d* and *f*). The knotter hook and twine disk revolve, the knot

is tied, the ends are cut, and the bundle is thrown out by the discharge arms.

The knot is pulled from the hooks of the knotter by the action of the discharge arms against the bundle. The twine is always retained in the eye of the needle and in the twine-holding disk so that the same operation may be repeated when the next bundle is formed.

Larger bundles may be made by setting the trip hook



Courtesy of Deere & Co.

FIG. 174.—Bundle carrier.

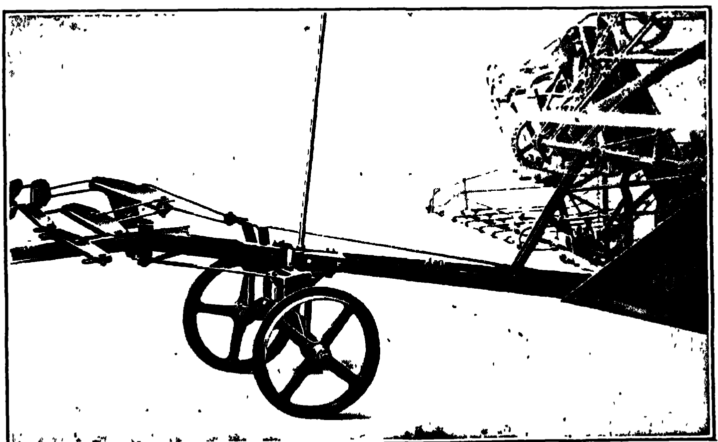
(Fig. 170, *b*) farther back. Several holes are provided for this purpose. Tighter bundles may be obtained by increasing the tension of the compressor spring, shown in Fig. 173, *D*. The bundles may be made tighter also by increasing the tension of the trip-stop spring (Fig. 173), in the type of binder here illustrated.

Adjustments similar to those described and illustrated above are provided on all types of binders.

Several studies emphasizing the care and adjustment of the binding attachment will be given at the end of this chapter.

16. Bundle Carrier (Fig. 174).—The bundle carrier is attached to the main frame of the binder. The bundles are thrown by the discharge arms from the deck of the binder to the bundle carrier. When several bundles have accumulated on the bundle carrier, the operator dumps it by means of a foot lever located near the driver's seat. A coil spring returns the bundle carrier to its original position after the bundles have been dumped off.

This action of the bundle carrier makes it possible to drop



Courtesy of Deere & Co.

FIG. 175.—Tongue truck.

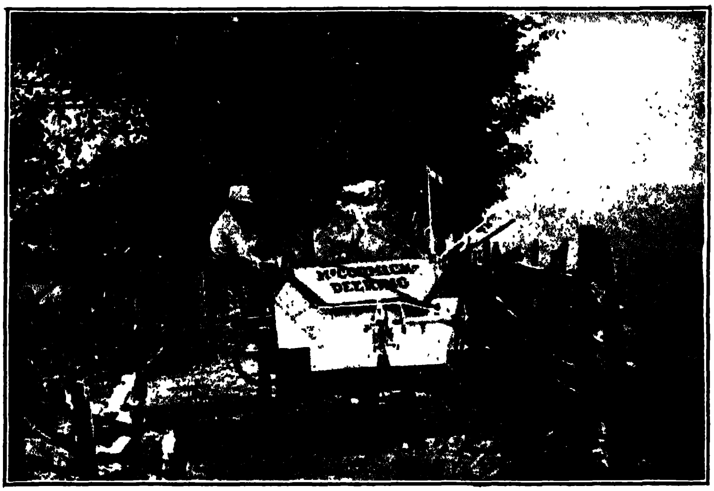
the bundles in rows across the field. This saves much time in later harvesting operations.

17. Tongue Truck (Fig. 175).—Horse-drawn binders are usually equipped with a tongue truck. This requires the use of both a stub pole and a long pole. A tongue truck is very desirable. It supports the forward end of the binder and relieves the horses' necks of all weight. The stub tongue is connected to the main frame and braced to a point near the inside divider. Wooden or steel eveners are commonly fur-

nished. Three or four horses are used with the 7-ft. and 8-ft. binders.

18. Tilting Lever (Fig. 167, *e*).—The long tilting lever is connected to the stub pole by means of steel braces. The setting of this lever, through the action of the tilting crank (Fig. 167, *f*), controls the tilt of the cutter bar. The guards may be tilted down for picking up lodged or tangled grain.

19. Transport Trucks (Fig. 176).—It is very desirable to have a binder equipped with transport trucks. When these are used the stub pole and tongue truck are connected underneath the outer end of the platform. The axles of the transport trucks are carried in castings bolted to the main frame. (See Fig. 154, *B* and *C*). The binder is drawn from the outer end of the platform. This is very convenient when traveling on narrow roads or through woods, etc., as the machine requires less space when drawn in this manner than when in the working position.

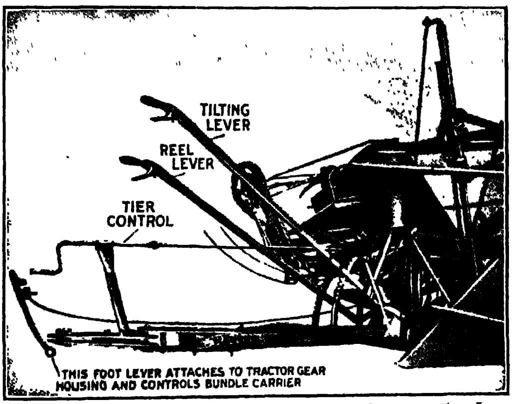


Courtesy of International Harvester Co.

FIG. 176.—Transport trucks.

TRACTOR BINDERS

1. Stub-pole Tractor Hitch.—Binders that are built to be drawn by horses can very easily be operated with tractors. A short pole can be connected from the binder to the draw bar of the tractor. Such combinations, however, will require two men to operate them. One man must drive the tractor and another must occupy the seat of the binder and operate the various levers, trip the bundle carrier at proper intervals, etc.



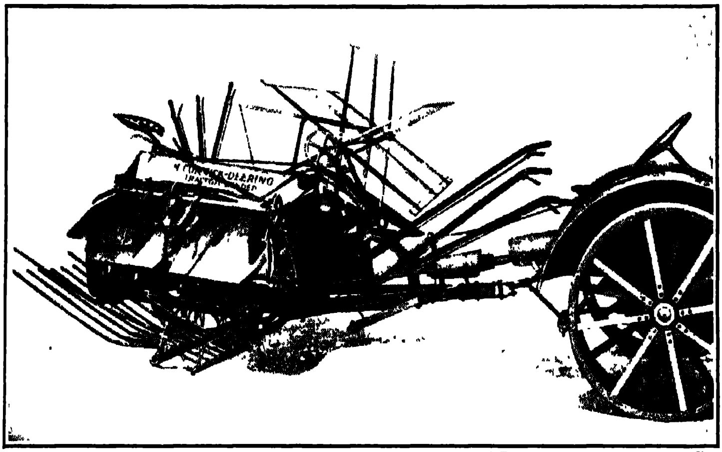
Courtesy of Massey-Harris Harvester Co., Inc.

FIG. 177.—One-man control tractor hitch.

2. One-man Control Hitch (Fig. 177).—To do away with the necessity for the extra man, special tractor-binder control hitches have been designed. These make possible the control of the binder from the seat of the tractor.

3. Tractor Binders (Fig. 178).—Special tractor binders are built in 8- to 10-ft. sizes. These are suitable for use with medium-sized farm tractors. The power for driving tractor binders is taken directly from the tractor. No chain is used on the main wheel of the binder, as is done in horse-drawn binders. A special shaft is mounted in the binder frame which is geared

at the rear end of the binder to the crankshaft. The driving power is transmitted from the crankshaft sprocket to the other parts in the same manner as in horse-drawn binders.



Courtesy of International Harvester Co.

FIG. 178.—Tractor binder with power take-off.

All the levers are mounted on the stub pole within easy reach of the tractor seat. The bundle carrier is operated by a trip rope.

LABORATORY STUDY NO. 13

To inspect, locate, and name the parts that transmit power to the various parts of the binder.

Equipment Necessary.—Complete binder.

Procedure.

1. Begin with the main-wheel sprocket and name in order the parts that transmit power to the sickle.
2. Examine the connections, gear contacts, chains, or bearings of all such parts, to determine if any are badly worn.
3. Locate the adjustment for taking up wear in the bevel gears (Fig. 156, *B*).
4. Note the manner in which the main chain is placed on the sprocket. (See Fig. 161 for correct method.)
5. Starting with the crankshaft sprocket (Fig. 163, *a*) list in order the parts that transmit power to the various elevator rollers.
6. Examine the parts listed above to determine if any are badly worn.
7. Starting with the main-drive roller, list in order the parts that transmit power to the reel and adjuster (Fig. 167).
8. Examine the parts listed above to determine if any are badly worn.

LABORATORY STUDY NO. 14

(Fig. 179)

To thread the binder needle with the binding twine, and test the knotter.

Equipment Necessary.—Binder with all parts of binding attachment, twine can, twine guides, and tension, one ball of binding twine.

Procedure.

Note.—The following directions apply particularly to the McCormick binder, but may be followed in general for any other make.

1. Pull the twine end out from the center of the ball. Pass

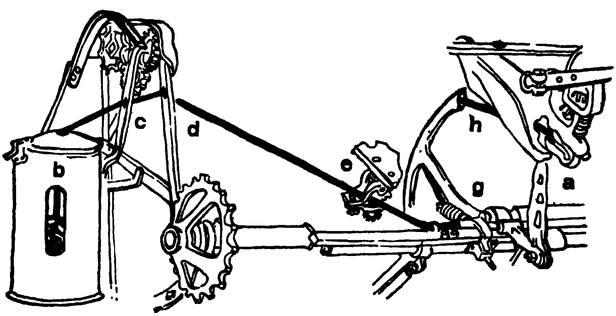


Fig. 179—Threading the needle.

it through the holes in the top of the twine can (Fig. 179, *b*) and close the cover.

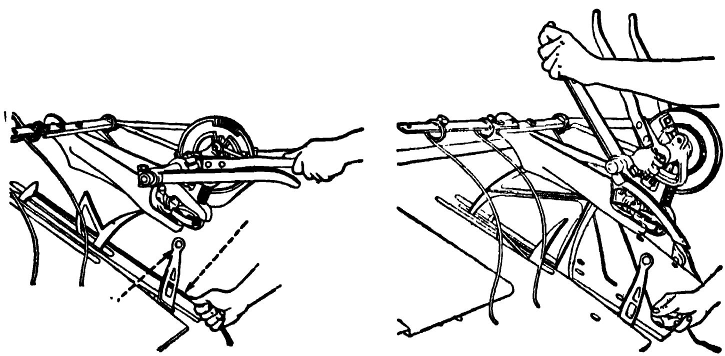
2. Pass the twine through the holes in the braces (Figs. 179, *c* and *d*).

3. Spring open the roller tension (Fig. 179, *e*) and pull the twine through it. This tension may be adjusted by means of a regulating nut. It should be so tight that no slack is permitted in the twine between the tension and the twine-holding disk.

4. Pass the twine through the eyelet shown in Fig. 179, *g* and also through the eyelet on the back of the needle.

5. Thread the twine through the needle as indicated by the dotted lines (Fig. 179, *h*) and pull several feet through the eye of the needle.

6. Hold the free end of the twine tight with one hand. Pull back the trip hook (Fig. 170, *b*) and revolve the discharge arms



A *B*

Courtesy of International Harvester Co.

FIG. 180.—Entering twine into twine holding disk.

while holding the twine taut. (See Starting Position, Fig. 180, *A*.)

7. Continue the revolution of the discharge arms (Fig. 180, *B*). This causes the needle to pass the twine into the twine-holding disk, where it is retained. Pull the knot off the knotter hook.

8. Test the knotter by tying several knots. To do this, the following steps are necessary:

(*a*) Pull a little twine (about 1 ft.) through the needle and hold it taut with one hand.

(*b*) Pull back the trip hook.

(*c*) Make one complete revolution of the discharge arms.

(*d*) Pull the knot off the knotter hook.

LABORATORY STUDY NO. 15

To locate and operate the various levers and adjustments of the binder.

Equipment Necessary.—Complete binder.

Procedure (Refer to Fig. 166).

1. Sit in the operator's seat and, by testing each lever or adjustment, locate the following:

   (*a*) Reel-raising lever.
   (*b*) Reel-tilting lever.
   (*c*) Binder-tilting lever.
   (*d*) Bundle-carrier foot lever.
   (*e*) Shifting lever for binding attachment. This shifts the binding attachment forward or backward.
   (*f*) Adjuster lever.

2. Locate the following parts:

   (*a*) Main-wheel raising crank.
   (*b*) Grain-wheel raising crank.

3. Operate each of the levers until the purpose and action of each is clearly understood.

Job No. 25

TO OVERHAUL AND REPAIR A GRAIN BINDER

Note.—In order to simplify the procedure, this job will be divided into six parts.

Operations Necessary to Perform the Job.

Part I.—Main Wheel and Countershaft

1. Inspect alignment of main wheel.
2. Test bearings of main wheel.
3. Examine main-wheel sprocket and main chain.
4. Test main-wheel raising device.
5. Check alignment of main sprocket and clutch sprocket.
6. Test clutch and clutch spring.
7. Replace bearings on countershaft if necessary.
8. Take up end play on countershaft.
9. Clean and oil bearings of main-wheel shaft and countershaft.

Part II.—Elevators, Rollers, Canvases

1. Remove and repair canvases.
2. Test rollers and replace worn bearings.
3. Square up elevators.
4. Inspect apron chains and sprockets. Test alignment of apron sprockets.

Part III.—Cutter Bar, Sickle, Pitman

See instructions for repairing cutter bar, sickle, and pitman on mowers, Job No. 23, pages 210 and 211.

Part IV.—Reel

1. Replace worn gears, sprockets, or chains that drive the reel.
2. Test bearings of reel shaft.
3. Adjust reel shaft.
4. Adjust reel slats.
5. Replace broken slats or arms.
6. Paint all reel parts.

Part V.—Binding Attachment

1. Test knotter.
2. Replace worn cams or gears.
3. Adjust needle pitman.
4. Tighten packer bearings.
5. Sharpen twine knife.

Part VI.—Miscellaneous

1. Test action of all levers.
2. Adjust tension of bundle-carrier spring.
3. Lubricate all chains.
4. Paint platform.
5. Oil all bearings.
6. Grease or oil axles of tongue truck.
7. Inspect grain-wheel bearings.

Description of Operations.

Part I.—Main Wheel and Countershaft

1. Test the main wheel to see that it is square with the frame. The raising pinions on each side of the main wheel should be entered equally into the side brackets of the frame. Each raising pinion has one marked tooth. This is to aid in getting the pinions properly entered into the teeth of the side brackets (Fig. 154).

2. Jack up the main frame and test the bearings on the main-wheel axle. (These are large roller bearings and seldom wear out.) Lubricate them well through the oil holes.

3. Examine the main-wheel sprocket and main chain for wear.

(*a*) Is the main chain assembled in the proper manner? (See Fig. 164.)

4. Test the main-wheel raising device and see that it works freely. Frequently the cotter pins used to attach the raising worm to the raising crank are not properly spread and prevent

the worm from turning. Lubricate these parts well with a hand oiler.

5. Check the alignment of the clutch sprocket and the main-wheel sprocket. Difficulty in keeping the main chain on is sometimes experienced because these sprockets are out of line.

Replace the clutch sprocket if it is badly worn.

6. Engage the clutch and test the tension of the clutch spring. Both the clutch and clutch sprocket should be replaced if the notches are worn.

7. Test the bearings of the countershaft. These are roller bearings and are easily replaced if necessary.

8. Adjust the countershaft to take up the wear between the bevel gear and the bevel pinion. To accomplish this it is necessary to force the countershaft outward by means of the adjustment shown in Fig. 156, *B*. It is also well to force the bevel pinion forward by putting a washer between the crank-shaft bearing and the bevel pinion.

9. Clean out the oil holes of the countershaft bearings and main-wheel bearings. Lubricate these bearings thoroughly.

Part II.—Elevators, Rollers, Canvases

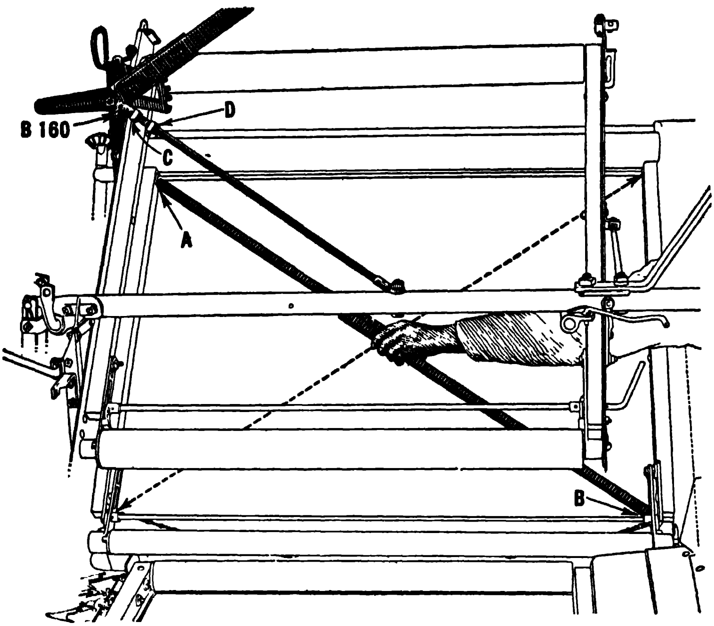
1. Remove all canvases. Examine the leather straps and replace any that are worn or broken. Inspect the canvas slats and see that the canvas is securely tacked to each slat.

2. Turn each roller in its bearings. See that all the rollers turn easily. Replace any worn bearings. Clean out all oil holes that lead to the bearings of the rollers and lubricate them well.

3. Square up the elevators. This may be done by testing with a carpenter's square or by measuring with a stick between diagonally opposite corners. The distance between each pair of diagonally opposite corners should be equal (Fig. 181).

The elevator brace rods may be shortened or lengthened to make these measurements equal.

4. Examine the elevator chain or apron chain. See that it is put on properly. Replace any sprockets that are worn. Check the alignment of all the sprockets over which the apron



Courtesy of Deere & Co.

FIG. 181.—Squaring the elevators.

chain runs. Clean out all the oil holes in the sprocket bearings and lubricate them thoroughly.

Part III.—Cutter Bar, Sickle, Pitman

For this problem the same procedure may be followed as for mowers. The repair work to be done on these parts is so similar to that necessary on mowers that the same outline will be satisfactory, with the following exceptions:

(*a*) Binders have no means of aligning the cutter bar.
(*b*) No provision is made for registering the sickle.
(*c*) Binder-sickle sections are not resharpened, but must be replaced when worn.

Part IV.—Reel

Binders with no outside reel support usually have an adjustment on the reel frame to raise the outer end of the reel shaft into place.

1. Examine the sprockets, gears, and chains that drive the reel. See that all are in proper alignment. Replace any worn parts. Be sure that the reel-driving chains are put on properly (Fig. 164).

2. Test the bearings of the reel shaft in the reel frame. These bearings are removable.

3. Adjust the reel shaft so that it hangs level. The outside end of the reel on used binders tends to sag down. Where outside reel supports are used, the outer end may be raised into position by shortening the chain attached to the outside bar.

4. Disconnect the reel-driving chain. Revolve the reel and make sure that none of the reel slats strike the inside or the outside divider. The inner ends of the reel slats should come to a position over the cutter bar, slightly before the outer ends.

5. Replace cracked or broken slats or arms.

6. Paint all wooden parts of the reel and the reel shaft.

Part V.—Binding Attachment

1. Tie several knots with the binder attachment to determine if all parts are working properly. To do this, refer to the directions in Laboratory Study No. 14, page 242.

Failure to tie properly may be caused by several things. The most common troubles are as follows:

(*a*) Knotter spring (Fig. 171, *e*) too tight.
(*b*) Knotter spring too loose.
(*c*) Twine-holding disk too tight. Adjust by the set screw (Fig. 171, *g*).

(*d*) Twine-holding disk too loose. Adjust with set screw (Fig. 171, *g*).
(*e*) Needle bent or out of adjustment so that it does not place the twine in the disk properly.
(*f*) Twine tension (Fig. 179, *e*) too loose.
(*g*) Twine tension too tight.

The following instructions are reprinted from the instruction book of the International Harvester Co. and refer to the McCormick-Deering grain binder:

"1. Keep roller tension tight (not too tight).

2. Do not try to regulate size or tightness of bundles with the tension on the twine or by adjusting the knotter spring.

3. If the bundle is thrown out not tied, find the reason in the following three causes.

(*a*) Twine-holding disk may be too loose, which allows the twine to slip out while knotter hook is making revolutions.
(*b*) Twine-holding disk may be so tight the twine cannot slip through disk. This will break the twine.
(*c*) Needle may not come down far enough to place upper twine in disk safely.

If bundle is thrown out not tied, with twine straight and no knot in it, the knotter spring is too loose, and may be adjusted.

Do this carefully, as the average operator will usually give the set screw a full turn each time he attempts an adjustment, and this is frequently the cause of failure to correct the trouble. Give the set screws a quarter of a turn each time a change is made. If the trouble is not overcome by adjusting in one direction, be sure and change the screw back to its original position. Then try adjusting in the opposite direction.

Don't make spring too tight on knotter or it will break the twine.

Needle is set at exactly the right point before binder leaves the factory and must not be changed. Binder works best when just enough tension is kept on twine to prevent it from getting slack.

2. Examine all working parts of the binder attachment and replace badly worn cams or gears.

Note.—Wherever two gears mesh together on the binding attachment, timing marks are provided on the teeth, for convenience when reassembling these gears. If such marks cannot be found, make punch marks on the gears before taking them apart. They must be assembled in the proper relation.

3. Lengthen the needle pitman if necessary (Fig. 173, *B*). In old binders it is often necessary to make the stroke of the needle longer in order that the needle may carry the twine to the twine-holding disk properly.

4. Tighten the bearings of the packers. These are usually made in halves. One half may be removed and filed down. This will allow the bearing to be drawn closer together.

5. Remove the twine knife and sharpen it with an oil stone. If it is badly worn, replace it with a new one.

6. Remove and clean the twine tension (Fig. 179, *c*). Frequently matter becomes wedged into the moving parts of this tension, so as to prevent its proper operation.

Part VI.—Miscellaneous

1. Test all the levers to see that they operate freely. Examine the lever detents and replace any that are worn.

2. Operate the bundle-carrier trip lever. Adjust the tension of the bundle-carrier return spring so that the carrier returns to its normal position quickly.

3. Oil all the chains used on the binder by brushing them with an old paint brush dipped in oil.

4. Paint the sheet-iron bottom of the platform to prevent rusting.

5. Oil all the bearings and moving parts of the entire machine before storing it away.

6. Remove tongue-truck wheels and examine the axles. Grease or oil these.

7. Remove the grain wheel and wash the roller bearing clean. Clean out the oil tube in the grain wheel which leads to this bearing. Replace roller bearing and grain wheel. Lubricate thoroughly.

LABORATORY STUDY NO. 16

TO LUBRICATE ALL PARTS OF A GRAIN BINDER

Equipment Necessary.—Complete grain binder; supply of a good grade of machine oil; sharp-pointed wire for cleaning out oil holes.

Procedure.

1. Locate all parts on both wheels that require oil (or grease).

   (*a*) Oil each part.
   (*b*) List each part oiled.
   (*c*) How many places are there to oil on the wheels?

2. Locate all places on the elevator rollers that require oil.

   (*a*) Oil each part.
   (*b*) List each part oiled.
   (*c*) How many places to oil on the elevators?

3. Locate all places requiring oil on the binding attachment.

   (*a*) Oil each part.

Note.—Remove the center section of the deck to oil packer cranks, etc.

   (*b*) List each part oiled.
   (*c*) How many places to oil on the binding attachment?

4. Locate all places to oil on countershaft, crankshaft, pitman, and sickle.

   (*a*) Oil each part.
   (*b*) List each part oiled.
   (*c*) How many places to oil?

5. Locate all places to oil on platform (not including sickle).

   (*a*) Oil each part.
   (*b*) Name each part oiled.
   (*c*) How may placed to oil on the platform?

6. Locate all places to oil on reel.

   (*a*) Oil each place.
   (*b*) Name each place lubricated.
   (*c*) How many places to oil on the reel?

7. Locate all places to oil on adjuster.

   (*a*) Oil each place.
   (*b*) Name each place lubricated.
   (*c*) How many places to oil on the adjuster?

8. How many places to oil on the entire binder?
9. Which of these need oil very often?

Job No. 26

TO OPERATE A GRAIN BINDER

Operations Necessary to Perform the Job.

1. Put twine in twine can and thread needle.
2. Lubricate all parts.
3. Operate binder idle for a few minutes.
4. Start cutting at one edge of field and continue around field.
5. Regulate height of cut.
6. Adjust reel levers.
7. Drop bundles at regular intervals.
8. Regulate adjuster lever.
9. Adjust binder-shifting lever.
10. Keep canvases at proper tension.
11. Adjust deck windboard.
12. Adjust platform deck.
13. Adjust back curtain.
14. Regulate size and tightness of bundles.

Description of Operations.

1. Tie the outside of one ball of twine to the inside of another and put both balls in the twine can. The twine should feed out from the inside of the top ball. Thread the needle as instructed on page 242.

2. Lubricate all parts of the machine as described on page 252.

3. Before entering the grain it is well to put the binder in gear and run it idle for a few minutes. This gives the operator a chance to see that all parts are working properly. This practice is especially desirable with a new machine. With a new machine, kerosene should be used as a lubricant for the first few minutes while the machine is running idle. This cuts the paint and loosens up the new bearings better and more quickly than oil.

After the new machine has been run idle for a few minutes with kerosene as a lubricant, stop and oil all bearings and working parts carefully.

Caution.—Always throw the binder out of gear when working on it while the horses or tractor is attached to it.

A good grade of oil should be used. The binder has many rapidly moving parts that will heat and wear out quickly if not well lubricated with good oil.

4. Binders are driven around the field, not back and forth across the field like the plow or cultivator. The work is started at one corner of the field, and the binder is driven clear around. Each succeeding swath is nearer the center of the field.

Some difficulty is experienced by beginners at the corners of the field. The swath cut must be kept full width at the corners. Otherwise a long, pointed strip (an acute angle) of uncut grain will be left at the corners. This makes turning very difficult.

If the field is fenced, the horses or tractor must be driven through the standing grain when the first swath around the field is cut. The grain that is thus left standing may be cut by running the binder around the field in the opposite direction. Unless the grain is over-ripe, very little will be lost by the horses or tractor passing over it while cutting the first swath.

5. The position of the raising cranks (on main wheel and grain wheel) determines the height of the platform above the ground. This distance may be regulated by the raising cranks so that the straw may be cut at any length desired.

For cutting short grain it is not advisable to lower the platform too much. It is better to tilt the guards downward.

The tilting lever (Fig. 167, *e*) should be set so that the cutter bar is nearly level. A slight tilt downward is desirable, where there are no obstructions in the field.

When the grain is badly lodged or tangled, the guards may be tilted down until they are close to the ground. This is also advisable for cutting short grain.

6. The reel should be adjusted by means of the reel-lifting and reel-tilting levers so that the reel fans strike the grain just below the heads. The reel should be set far enough back so that the cut grain is placed well on the platform. If it is set too far back the grain will be thrown over the rear of the platform.

The reel fans should not leave the grain until after it is cut. An important function of the reel fans is to hold the grain against the sickle while it is being cut.

7. Drop the bundles at equal intervals by operating the foot dumping lever.

The distance between "dumps," or windrows, will vary according to the grain. In heavy grain the bundles must be dumped more frequently than in light grain, consequently the windrows are nearer together in heavy grain. Bundle carriers are large enough to carry six or seven bundles easily. The first time around the field, the bundle carrier is dumped each time it is full. It must be dumped at the same place during each succeeding round.

8. The adjuster lever must be set so as to shape the butts of the bundles properly. Under ordinary conditions the adjuster should be set as far toward the front of the binder as possible. In short grain it is necessary to pull the adjuster toward the rear of the binder. This is done with the long rod, or adjuster lever, near the driver's seat. Moving the adjuster rearward causes it to push the cut grain also toward the back of the binder deck. This will result in the bundle being tied near the middle, which is always desirable.

9. The binder-shifting lever shifts the binding attachment backward or forward. It should be set so that the bundle is tied in the center.

10. The canvases should be kept just tight enough to prevent their slipping when loaded with grain. If they are too tight, unnecessary friction and wear is caused.

11. The windboard at the rear of the binder deck may be folded and locked into the position shown in Fig. 153. This leaves more open space on the deck, which is often desirable when cutting long straw.

12. The wooden platform deck is hinged to the rear of the platform. For short grain it should be raised to a vertical position. For long grain it should be lowered to the horizontal position, in which it forms an extension to the platform.

13. The cloth curtain, or wind break, at the rear of the platform may be swung forward or backward as required, to protect the grain on the platform from wind and to prevent its being carried over the rear of the platform.

14. The size of the bundles is regulated by the trip hook (Fig. 170, *b*). Moving the trip hook in makes the bundles smaller, moving it out makes them larger. Several bolt holes are provided at this point so that a considerable range of adjustment is possible. Small bundles are desirable for heavy, green, or tangled straw. Large bundles may be made if the straw is straight and dry.

The tightness of the bundle is regulated by the compression spring (Fig. 173, *D*) or by the trip-stop spring (Fig. 173). Increasing the tension gives a tighter bundle. Tight bundles are desirable for clean, dry straw, and loose bundles for tangled, green, or heavy straw.

FIELD TROUBLES

Grain binders give very little trouble when properly adjusted. They accomplish in a dependable manner a difficult and complex operation.

It is not practical to operate the binder when the straw is very wet, while the dew is heavy, or during a rain. Under such conditions much trouble is experienced with slipping canvases and with the straw winding up on the rollers.

Over-ripe grain also presents a difficult condition, as the action of the packers and discharge arms threshes out much of the grain, which is lost. The cutting must be done at the proper time for best results. Dry straw cuts easily and is handled without trouble by the various parts of the binder.

Some of the troubles that may occur in the field are given below, with the cause of each and the remedy for it.

1. Bundles Missed (not Tied).

Note.—Do not stop the binder because an occasional bundle is missed. If any real trouble exists, bundles will be missed frequently.

(*a*) Twine disk too loose (or too tight).

Remedy.—Adjust to proper tension.

(*b*) Twine tension too loose, or too tight, or tension rollers stuck.

Remedy.—Adjust to proper tension; oil tension rollers.

(*c*) Knotter hook too tight or too loose.

Remedy.—Adjust to proper tension.

Note.—Directions for making these adjustments were given on page 250.

(*d*) Twine knife too dull.

Remedy.—Remove and sharpen the knife or replace it with a new one.

(*e*) Needle bent or out of adjustment.

Remedy.—Straighten and adjust so that it places the twine in the twine-holding disk properly. The forward stroke of the needle must be sufficient to carry the twine into the disk. Keep the point of the needle sharp. The point should project slightly above the deck, when it is not in motion.

2. Bundles too Loose or too Tight.

Remedy.—Loosen the compressor spring to make looser bundles. Tighten it to make the bundles tighter.

3. Bundles too Large or too Small.

Remedy.—Move trip hook in for small bundles, out for large bundles.

4. Discharge Arms Continue to Revolve.—(They should revolve only when necessary to discharge the bundle.)

This is caused by the failure of the trip stop to engage properly with the driving dog opposite it. This failure may be due to some part sticking owing to lack of lubrication. It is usually caused by a worn trip stop or driving dog or a weak compressor spring (Fig. 173).

Remedy.—Replace worn parts.

5. Chains Come off Frequently.—The straw may be too wet. In this case it will wind around sprockets and rollers and force the chain off. Worn chain links, sprockets that are out of line, or chains that are too loose may account for the trouble.

Remedy.—Align sprockets and assemble chain properly, replacing it with new chain if necessary.

6. Canvases Slip or Stop.—The causes of this trouble are loose canvases or sticking rollers.

Remedy.—Tighten the canvases, lubricate and loosen the bearings of the rollers. Determine if the rollers are square with the elevators.

7. Bundles Drag on Bundle Carrier.—This is often caused by the foot lever and the rod which operates the bundle carrier being bent out of adjustment. The action of the foot lever should swing the bundle-carrier fingers back (or down) far enough to make the bundles slide off.

Remedy.—Adjust the rods between the bundle carrier and the foot lever, so as to give more backward (or downward) movement to the fingers of the carrier.

8. Bundle Carrier Does not Return Properly.—The cause is a weak return spring, which must be tightened or, if necessary, replaced with a new one.

9. Main Wheel Slips.—All binder parts stop. This may be caused by wet or slippery ground. Under such conditions the main wheel has no grip or traction.

Tight bearings, very heavy grain, bent shafts, or a compressor spring that is too tight may also cause the trouble. Broken chain links, chains that are too tight, or chains climbing up on the teeth of the sprockets may throw an additional load on to the binder which will cause the main wheel to slip.

Remedy.—See that all chains and sprockets are properly adjusted. Test all moving parts to locate the cause of excessive draft.

CHAPTER VIII

MANURE SPREADERS

The problem of distributing fertilizer is now met with in practically all parts of the United States. The number of machines used for the purpose has increased rapidly during the past decade. Modern machinery meets this problem well: distribution is rapid and uniform; the amount per acre may be accurately controlled; and the fertilizer is pulverized well while being distributed, thus being made quickly available. Machines are employed for spreading lime and distributing commercial fertilizer. The manure spreader, however, is now a standard part of the farm equipment. On many farms it is used more frequently than any other farm machine; hence, it will be discussed at length here.

The manure spreader is widely used. The quality of the work accomplished by this machine is so far superior to hand work, and so much more economical, that the manure spreader is commonly found on American farms.

The manure spreader should pulverize thoroughly and spread a uniform layer of the desired thickness. Bunching and lumps must be eliminated, and the desired rate of distribution must be maintained whether the machine is moving uphill or down.

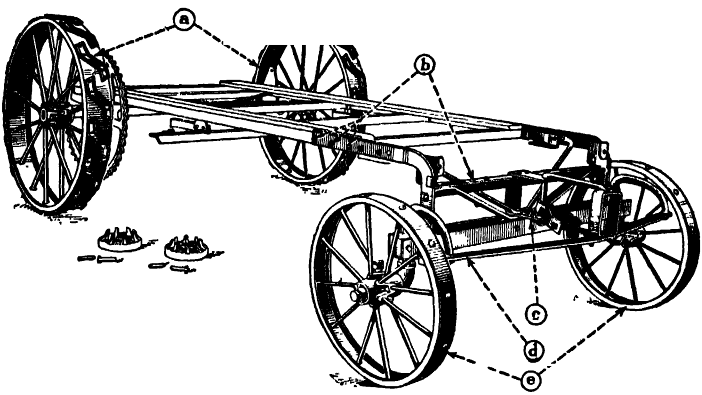
Adjustments are necessary to provide for a light top dressing as well as for a heavy application to be plowed under. Most manure spreaders can be adjusted to distribute from about 6 to 20 loads per acre.

Sizes.—The size is expressed in bushels. The size most widely used holds about 60 bushels of manure. Such a machine

is considered a load for two horses. Machines with a capacity of from 70 to 75 bushels are also manufactured. These usually require three horses. Either size is easily operated by a small farm tractor. They may be equipped with a stub pole for tractor operation.

CONSTRUCTION AND PRINCIPAL PARTS

1. Frame (Fig. 182).—The frame extends through the entire length of the machine. It is subjected to heavy strains and must be strongly built and well braced. The outer sills are



Courtesy of International Harvester Co.

FIG. 182.—Manure spreader frame and wheels.

made of steel. The cross sills may be of wood or steel. Diagonal braces are used to maintain the alignment of the main sills. Misalignment, sagging, or twisting would cause binding of the working parts, heavy draft, and frequent breakage of the driving mechanisms.

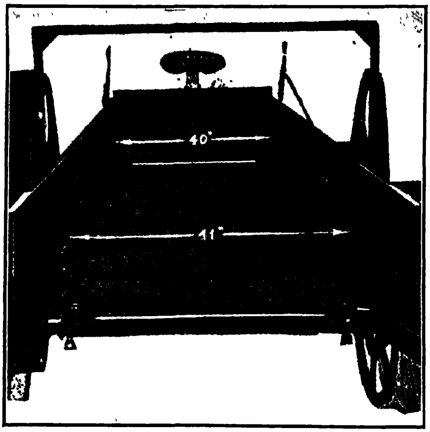
The frame is the central part of the machine, and on it many other parts depend:

(*a*) The front truck is connected to the front end of the frame (Fig. 182, *b*).

(*b*) The rear axle and wheels are attached to the rear end of the frame (Fig. 182, *a*).

(*c*) The frame supports the box, which holds the load, and the conveyor or apron, which moves the load.

2. Conveyor, or Apron.—The conveyor, or apron, carries the load slowly backward and delivers it gradually to the revolving beaters. An apron of the simple conveyor type has of late years become the standard. This type is shown in Fig. 183. It is made up of angle-steel slats which are connected at the outer ends to steel chain links. This apron, or chain of slats, is driven by a shaft near the rear of the spreader. Grease cups or some other means of lubrication are always provided on this drive shaft (Fig. 183). A sprocket is carried on either end of this shaft, to engage with and drive the apron chain. The front apron shaft is not a driving shaft.



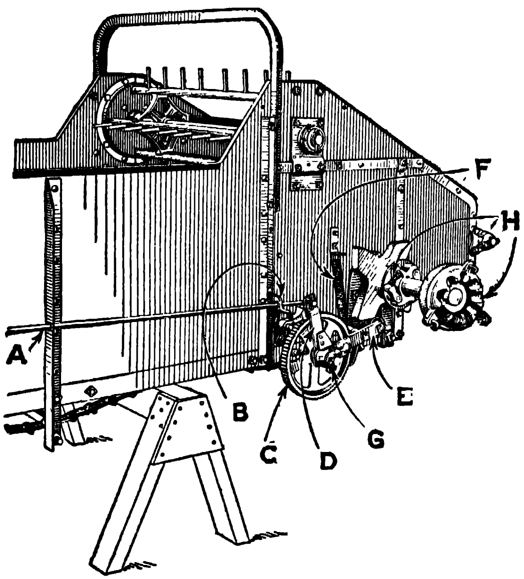
Courtesy of Massey-Harris Harvester Co., Inc.

FIG. 183.—Interior view of spreader box showing conveyor or apron.

One method of regulating the tension of the conveyor, or apron, is by means of the adjusting screws at each side of the front apron shaft (Fig. 188).

3. Conveyor or Apron Driving Device.—Figure 184 shows one type of apron drive. The large ratchet wheel (*C*) is keyed to the outer end of the conveyor drive shaft. A rocker arm (*G*) is also mounted over the end of the conveyor left. A pawl is secured to the rocker arm. The rocker arm is depressed by the large, four-point cam on the rear axle. It is returned by the large coil spring (*F*).

The motion of this rocker arm causes the feed pawl to engage with the teeth on the ratchet wheel (*C*) and drive it. An adjustable feed stop (*D*) regulates the number of teeth engaged by the feed pawl. In this way the speed of the conveyor shaft is regulated. The setting of this feed stop, therefore, determines the rate of distribution or the number of loads



Courtesy of Deere & Co.

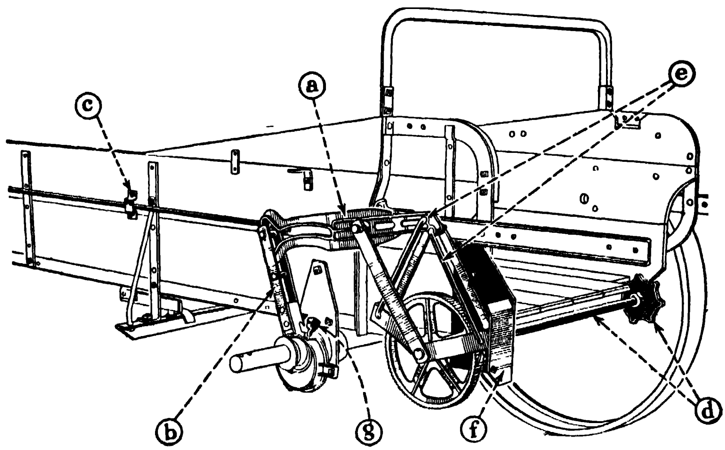
FIG. 184.—One type of apron-driving device.

per acre. The position of the feed stop may be regulated from the seat by means of the long rod (*A*).

Another type of conveyor drive is shown in Fig. 185. Here the power for driving the conveyor is taken from the rear axle by an eccentric. The motion of this eccentric is carried through the rocker arm (*b*) and the rods (*e*) to the feed pawls which drive the large ratchet wheel. The ratchet wheel is keyed fast to the conveyor drive shaft (*d*). The stroke of the

rocker arm is regulated by means of the feed rod (*c*) which is moved by a lever at the front of the spreader. The length of the stroke of the rocker arm determines the number of teeth engaged by the feed pawls. This accordingly controls the rate of distribution.

4. Rear Axle (Fig. 186).—The rear axle supports most of the weight of the machine. It is a driving axle or " live axle " and furnishes the driving power for all the working parts. The



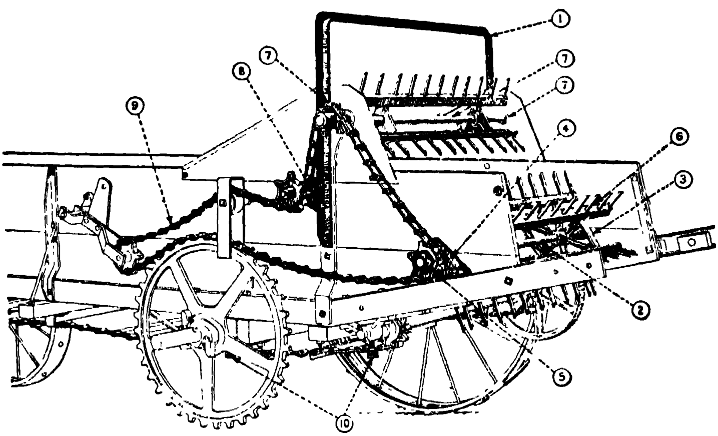
Courtesy of International Harvester Co.

Fig. 185.—Another type of apron-driving device.

placement of the rear axle varies on different types of spreaders. In some it is placed above the main frame, and in others below. Thus the weight of the frame and the load is either carried above or suspended from the rear axle. The rear wheels drive the main axle by means of pawls and ratchets. The construction and action of pawls and ratchets are discussed in Chapter III, on page 112, and are illustrated in Fig. 81. Power for driving the beater is secured from a large sprocket, which is keyed to the main axle (Fig. 186).

5. Beaters (Fig. 186).—Spreaders are now commonly equipped with two beaters, as shown in Fig. 186. The horizontal bars of the beater are made of steel. The teeth are usually riveted into the bars.

Both beaters have the same direction of rotation. The upper or smaller one pulverizes and discharges the upper part of the load. The lower and larger beater handles the main part of the load. The upper beater makes about nine revolu-



Courtesy of Emerson Brantingham Implement Co.

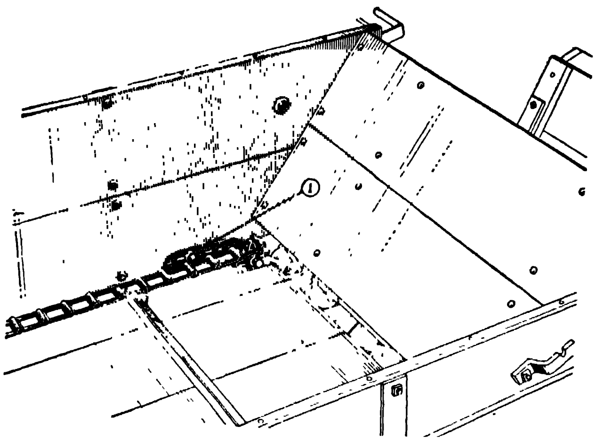
FIG. 186.—Beaters and beater drive chain.

tions to one of the main wheels. The lower beater turns at the rate of about six to one.

Beaters should be well supported at both ends by large, easily lubricated bearings. The pressure of the load against the beaters and the work of pulverizing is heavy. Strong construction, adequate bracing, and good bearings are essential in beater construction. Some machines are now being equipped with roller bearings. This is an excellent practice.

6. Beater Drive (Fig. 186).—The beaters are usually chain driven. The power is taken from a large drive sprocket keyed

fast to the rear axle. This sprocket also carries the main drive pawls. When the spreader is in action a large chain (*9*) is lowered onto the drive sprocket as indicated in Fig. 186. This chain is raised from the sprocket when the load has been distributed. Sprockets are mounted on each beater shaft (Fig. 186, *7* and 186, *5*). The drive chain passes over these sprockets and under an idle sprocket or chain tightener (*8*). An angle



Courtesy of Emerson Brantingham Implement Co.

FIG. 187.—Front endgate and conveyor tightener.

cross tie (*1*) is used to maintain proper alignment and spacing of the beater shafts.

7. Box (Fig. 183).—The spreader box holds the load of manure. It is made up of the following parts:

(*a*) bottom;

(*b*) sideboards;

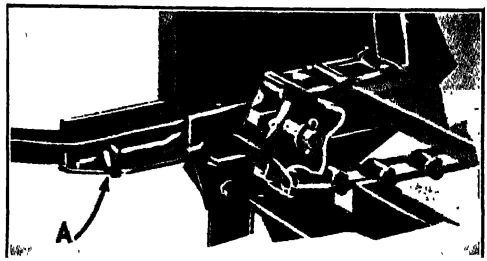
(*c*) front endgate;

(*d*) rear endgate (not used on all makes).

The bottom of the box in the late type of machines is tight. It is constructed of wood. Matched flooring material, such as yellow pine, is frequently used. This construction prevents loss in distributing liquid manure. It also prevents material

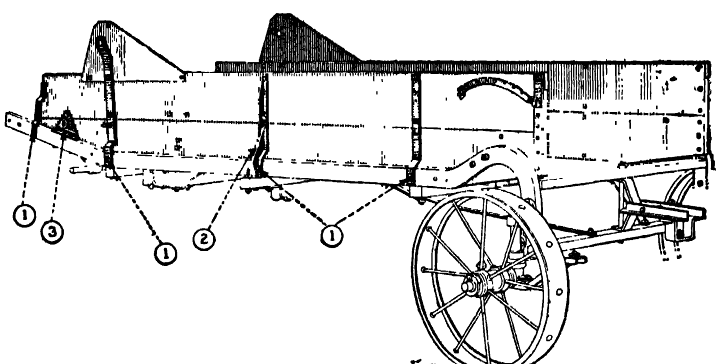
from falling through and collecting on the under side of the apron, as frequently happened in the open-bottom type of spreader.

The *front endgate* slants forward as shown in Fig. 187, making it possible to heap up the load in front. When the load is carried backward by the conveyor, the top of the heap will fall forward against the slanting endgate and thus be leveled out. The location of one of the front conveyor sprockets and apron tightener is shown in Fig. 187, *1*. Another type of apron tightener is shown in Fig. 188, *A*.



Courtesy of Massey-Harris Harvester Co., Inc.

FIG. 188.—Conveyor or apron tightener.



Courtesy of Emerson Brantingham Implement Co.

FIG. 189.—Connection of sideboards to frame.

The sideboards are bolted to the main sills with irons such as those shown in Fig. 189, 2. Knee braces (2) are used for adjusting the sideboards. Threads on these braces make it possible

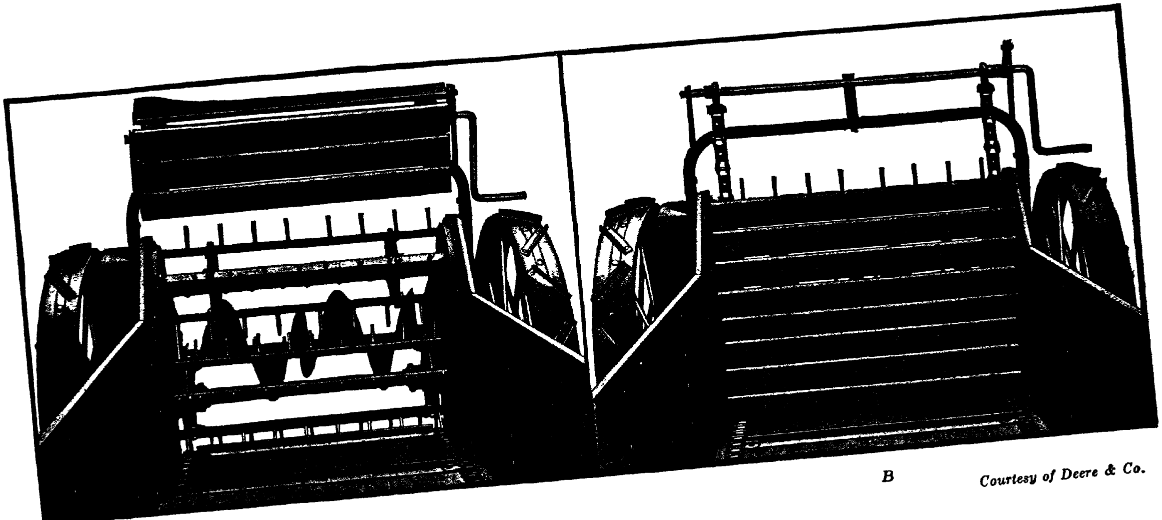
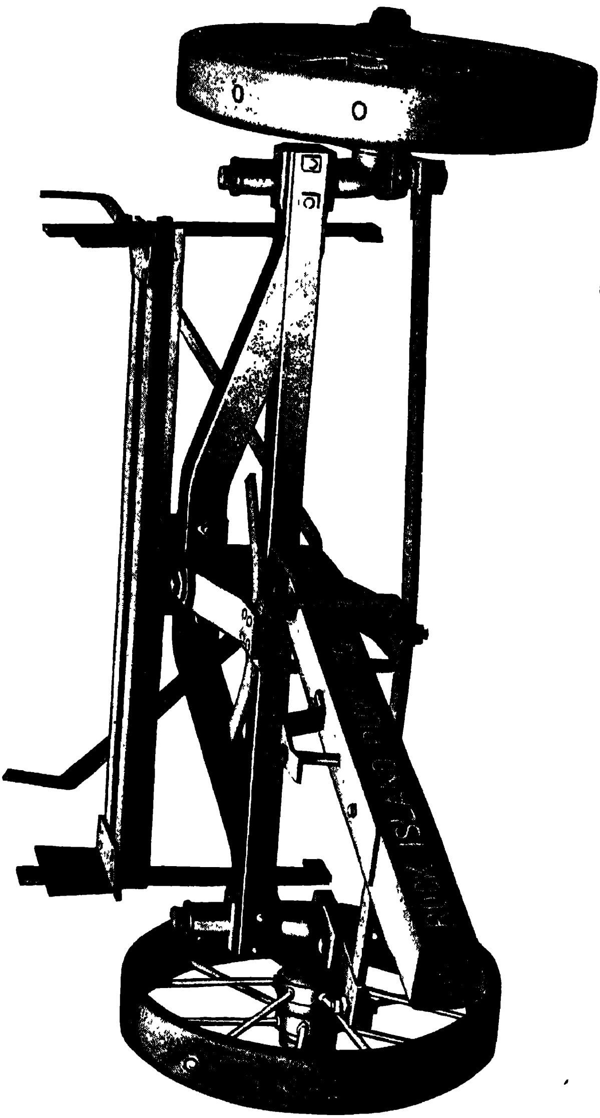


FIG. 190.—Rear endgate.



Courtesy of Rock Island Plow Co.

FIG. 191.—Front truck.

to bow in the sideboards a trifle at the center. This tends to loosen the load when it reaches the beater, and prevents binding.

One make of spreader is furnished with a rear endgate. Figure 190, *B*, shows the endgate lowered, ready for loading. Figure 190, *A*, shows it raised or in position of unloading. The rear endgate is especially useful when distributing wet manure. It prevents loss on the way to the field.

An inside view of the box is shown in Fig. 183. The box is narrower in the front than in the rear. This fact causes the load to loosen as it moves backward, thus lessening the strain on the beaters. Note the cross tie used to strengthen the rear of the box in Fig. 183.

8. Front Truck (Fig. 191).—The conditions under which manure spreaders are used require a front truck of careful design and sturdy construction. Short turning is necessary, as the machine must often be loaded from barnyard corners that are difficult of access. Complete covering of the corners of fields also requires short, square turns. The machine is often used on frozen fields and on rough ground, as when driving across corn rows. The strain on the whole machine, and especially on the front truck, is severe.

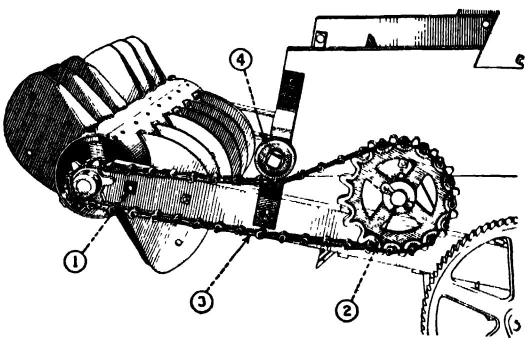
The automobile type of front truck is used on practically all makes of spreaders. This construction requires a fixed front axle, with short pivotal axles or steering knuckles projecting from it. The wheels are mounted on the short pivotal axles. A truck of this type facilitates steering, makes short turning possible, and eliminates " whipping " or jerking of the pole on rough ground.

The principal parts of a typical front truck may be seen in Fig. 191. A fixed steel axle is combined with the front bolster. This extends across the entire width of the machine. The pivotal parts of this assembly, which correspond to the steering knuckles in an automobile, are shaped as shown in Fig. 191. They are mounted vertically in suitable bearings at each end of the front bolster or fixed axle. The horizontal part of the pivotal axle carries the front wheels. Projecting from each

pivotal axle is a short, flat bar or steering arm. Each steering arm is connected by an adjustable drag link to the bracket through which the pole passes. The rear of the pole is attached with a pivotal connection to the center of the front axle.

When the pole swings to one side in making a turn, the drag links move both wheels in the same direction. As the pivotal axle is close to the hub of the wheel, turning is easily accomplished.

The front wheels are made of steel. The tires vary from $4\frac{1}{2}$ to $5\frac{1}{2}$ ins. in width and from 26 to 30 ins. in height. The



Courtesy of Emerson Brantingham Implement Co.

FIG. 192.—One type of wide-spread device.

wheels are retained on the axles by collars which may be adjusted to take up wear.

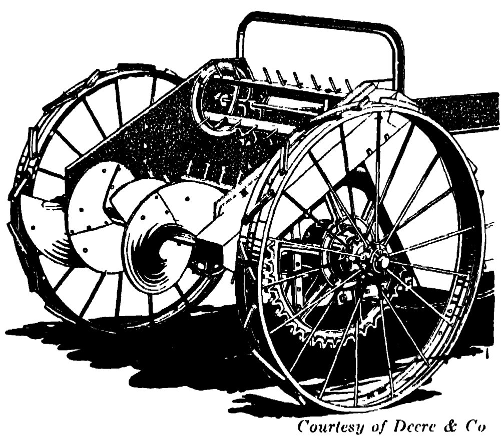
9. Rear Wheels (Fig. 194).—The rear wheels are also made of steel. They vary in height from 40 to 44 ins. on the various makes of spreaders. The width of the tires is from 4 to 6 ins. The rear wheels are equipped with angle lugs to secure good traction.

The rear wheels drive the rear axle by means of pawls and ratchets. The pawl holder is keyed or pinned to the rear axle. The ratchet, with the teeth which engage the pawls, is frequently cast into the hub of the wheel. When the machine is moving

forward the rear wheels drive the main axle. When it is backed up, however, the ratchet or teeth in the hub of the wheels slip over the pawls and do not drive the axle. This action is discussed on page 112, Chapter III (see Fig. 81).

10. Wide-spread Device (Figs. 192 and 193).—It is desirable to have the manure spread wider than the tread of the wheels. In other words, a spreader 6 ft. wide should distribute the manure over a strip from 7 to 8 ft. in width. This makes it unnecessary to lap over the preceding round with the spreader wheels, and lessens packing of the soil on wet fields.

The wide-spread device is in the nature of a third beater. Figure 192 shows one type of wide-spread mechanism. It is composed of a series of heavy steel blades, spirally arranged about a central shaft. The beaters throw the manure against the blades of the wide-spread mechanism. This revolves faster than the beaters or about fifteen times as fast as the main wheels. One-half of the blades are inclined toward the left and throw toward the left; the other half are inclined toward the right and throw toward the right. This widens out the spread without skimping the center. The wide-spread device is bolted to the rear of the frame as shown in Fig. 192, *1*. It is driven by the chain (*3*) from the sprocket (*2*) which is mounted on the end of the beater shaft. An idler pulley (*4*) is provided for adjusting the tension of the chain.



Courtesy of Deere & Co

FIG. 193.—Another type of wide-spread device.

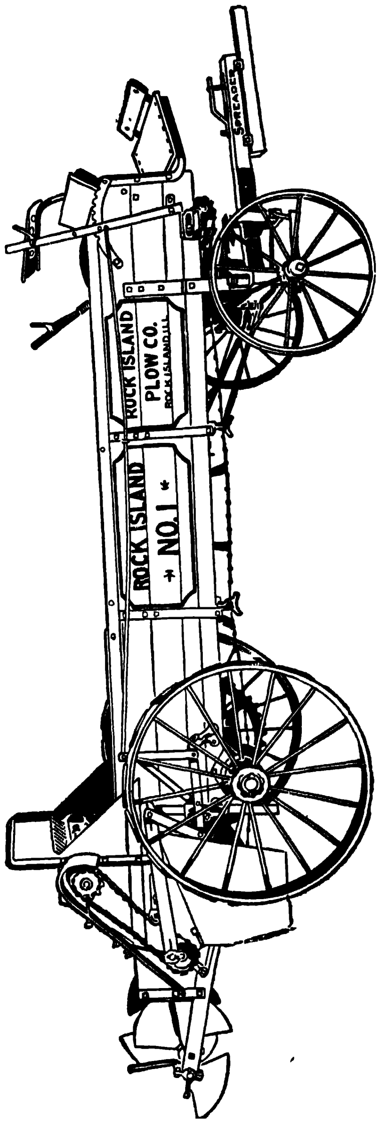
Figure 193 shows another type of wide-spread distributor.

This is in the form of a spiral beater. One-half of the spiral is inclined to the right, and one-half to the left. In this way the width of spread is increased.

11. Levers (Fig. 194).—Two levers are usually provided on spreaders. One is the feed lever, which regulates the rate of distribution. The other is the throw-out lever, which controls the beaters.

These levers are usually placed near the seat. The setting of the feed lever determines the number of teeth on the ratchet wheel to be engaged by the feed pawl. Moving the throwout lever raises or lowers the main drive chain shown in Fig. 186, *9*.

12. Stub Pole, or Tractor Hitch.—A long pole and a two-horse or three-horse evener is the standard equipment for a manure spreader. The only change necessary, however, to operate the machine with a tractor,

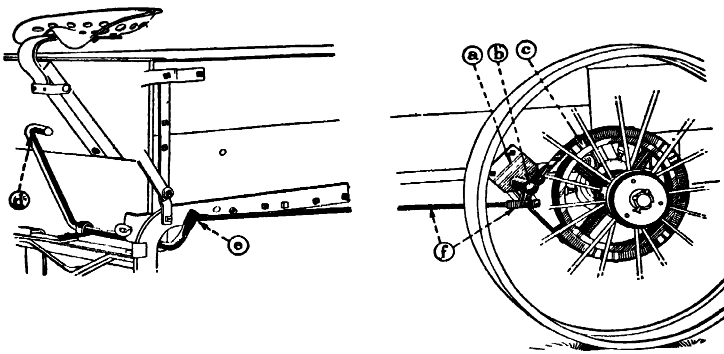


Courtesy of Rock Island Plow Co.

FIG. 194.—Standard type of manure spreader.

is to put in a short, stub pole. A stub pole, or tractor hitch, of this type is usually designed so that it may be adjusted to suit the height of the tractor draw bar.

13. Brake (Fig. 195).—A brake may be procured on some makes of spreaders. It is very desirable in hilly sections and makes it easy to fertilize fields that would otherwise be very



Courtesy of International Harvester Co.

FIG. 195.—Construction of brake.

difficult. Reference to Fig. 195 will show how the brake is installed. A friction wheel is attached to the main axle, and friction band is placed over this wheel. The band (Fig. 195, *c*) is operated by the rod (*f*) and the connection (*b*). These brake-operating parts are bolted to the main frame by means of the bracket (*a*).

Job No. 27

TO REPAIR A MANURE SPREADER

Operations Necessary to Perform the Job.

1. Replace main-drive pawls and springs in the rear wheels.
2. Replace feed pawls and springs if necessary. Examine ratchet wheel and all parts of conveyor drive.
3. Inspect and clean out bearings of conveyor drive shaft and front conveyor shaft.
4. Inspect bearings of beaters and wide-spread device. Clean, lubricate, and tighten all these bearings. Replace any that are badly worn.
5. Straighten beater teeth.
6. Remove, clean, and oil beater drive chain.
7. Inspect conveyor chain, tighten slat connections, and replace any worn links.
8. Repair and adjust front truck.
9. Lubricate all parts thoroughly.
10. Paint and reassemble all parts.

Description of Operations.

1. Jack up the rear end of the spreader until the wheels are off the floor. Place wooden blocks under the rear sills. Remove the rear wheels so as to get at the main drive pawls. Examine these pawls carefully. If the driving edges have worn down to a round edge, replace them with new ones. Worn pawls or broken or weak pawl springs cause much trouble. Test the tension of all the pawl springs. If any are weak, replace them.

2. While the rear wheels are off it is easy to get at the conveyor driving parts. Examine the feed pawls. It is usually advisable to replace these parts. Test the tension of the feed-pawl springs. Replace them if necessary. Clean out all the teeth on the ratchet wheel and wash it off with kerosene.

3. Inspect the bearings of the conveyor or drive shaft.

Clean off any dried grease or other accumulation. Replace the bearings if necessary. Make sure that the grease tubes leading to these bearings are open. Examine the bearings of the front conveyor shaft or sprockets. Clean out the oil holes.

4. Examine carefully all the bearings on the beater shafts and wide-spread device. Clean them out thoroughly. Kerosene may be used for cleaning them out. Usually the ends of the beater shafts will be found wrapped with straw.

5. Beater teeth become bent and loosened. They must be straightened out and riveted tightly into the beater bar.

6. Remove the beater drive chain. Wash it out thoroughly by immersing it in kerosene. Replace badly worn links. Then immerse the whole chain in oil. Used crank-case oil from tractors or automobiles is suitable for this purpose.

7. Inspect the links of the conveyor chain and replace worn links. Tighten any loose connections between the conveyor slats and the conveyor chain. Adjust the tension of the apron. Straighten the conveyor slats.

8. Jack up the front end of the spreader until the front wheels clear the ground. Remove the front wheels and examine the pivotal axles. These are likely to show considerable wear, particularly if they have not been well lubricated. Replace the pivotal axles if necessary. Tighten the bearings of the pivotal axles in the front bolster. Adjust the drag links so that the wheels toe in slightly at front.

9. Lubricate all parts thoroughly. The principal places to lubricate are as follows:

(*a*) front wheels;
(*b*) front conveyor-shaft bearings;
(*c*) lower beater bearings;
(*d*) upper beater bearings;
(*e*) wide-spread device;
(*f*) conveyor drive-shaft bearings;
(*g*) rocker arm for conveyor feed;
(*h*) idler sprocket bearing for beater chain.

Where grease cups or fittings are provided, use a good grade of cup grease. If oil holes are used or fittings for the use of oil are provided, use a good grade of machine oil, being sure that it is fluid enough to flow freely in cold weather.

10. Painting is very desirable, particularly for the wooden parts of the spreader box. The pole also should be painted or given a coat of linseed oil. Metal parts should be painted to prevent rusting.

11. Reassemble all parts and, while the machine is still jacked up, set both levers in working position. Turn the rear wheels and see that all working parts move freely.

Job No. 28

TO OPERATE A MANURE SPREADER

Operations Necessary to Perform the Job.

1. Lubricate machine thoroughly.
2. Place feed lever and throw-out lever in " neutral " or " off " position.
3. Load spreader.
4. Drive to field.
5. Lower drive chain on to beater or driving sprocket.
6. Set feed lever.
7. Start machine steadily, not with a jerk.
8. Put feed lever in neutral when turning.
9. Clean out spreader bottom.

Description of Operations.

1. Lubricate the machine as described in Job No. 27.

2. Place the feed lever and throw-out lever in neutral. This should always be done before beginning to load. If the feed lever should be left on, breakage of the conveyor driving parts would result. The load would be forced back against the beaters as soon as the machine started. This would cause the load to jam against the beaters (which would not be revolving) and breakage would be certain to occur. If rear endgate is used, have it in position for loading (Fig. 190, *B*).

3. Begin loading at the front of the machine and progress toward the rear. Load until even with the sides and then round off or heap up the load in the center. The manure should never hang over the sides. Do not have the rear of the load packed too tightly.

4. Before starting to the field, make sure that both levers are in neutral.

5. Stop the machine and lower the beater driving chain on to the main sprocket.

6. Set the feed lever in the notch that will give the desired amount per acre. Usually these notches are numbered. The numbers refer to the loads per acre that will be distributed.

7. Start the machine steadily. It is a heavy load. All the working parts must start action immediately and, as a result, the load is heavy at the start.

8. Always put the feed lever in neutral when turning.

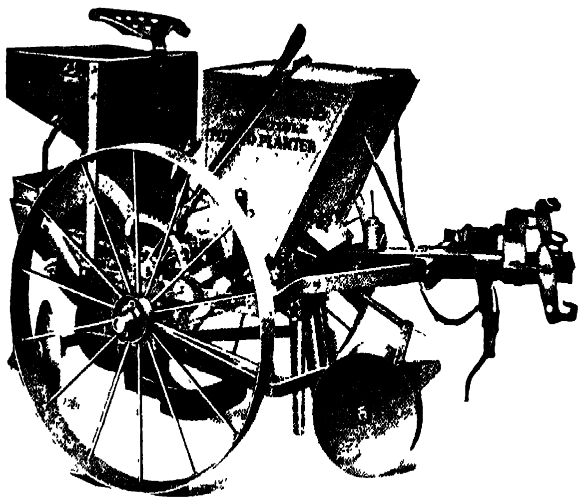
9. Clean out the spreader bottom after the load has been distributed. This may be easily cleaned out by allowing the conveyor, or apron, to continue moving for a part of the return trip from the field. For this purpose the feed lever may be set for the fastest speed. Be sure, however, to set the feed lever in neutral before loading up again.

CHAPTER IX

POTATO PLANTERS AND POTATO DIGGERS

POTATO PLANTERS

There are two principal types of potato planters: the one-man planter, which is illustrated in Fig. 196; and the two-man planter (Fig. 197). The former is the more widely used.



Courtesy of Fred H Bateman Co.

FIG. 196.—One-man potato planter (single row).

This machine is equipped with a mechanical picking device which drops the seed at regular intervals. In the two-man machine the work of spacing the distance between seeds is not entirely mechanical. One man frequently has to place the seed in the seed carrier buckets by hand. This work requires his

entire attention, so that a second man is required to drive the machine. It is claimed that the two-man planter is more accurate than the one-man machine. The limited extent to which it is used in potato-growing regions, however, would seem to demonstrate that the one-man planter is, in general, the more satisfactory.

The potato planter should open a furrow of proper depth for

Courtesy of Fred H. Bateman Co.

FIG. 197.—Two-man potato planter (single row).

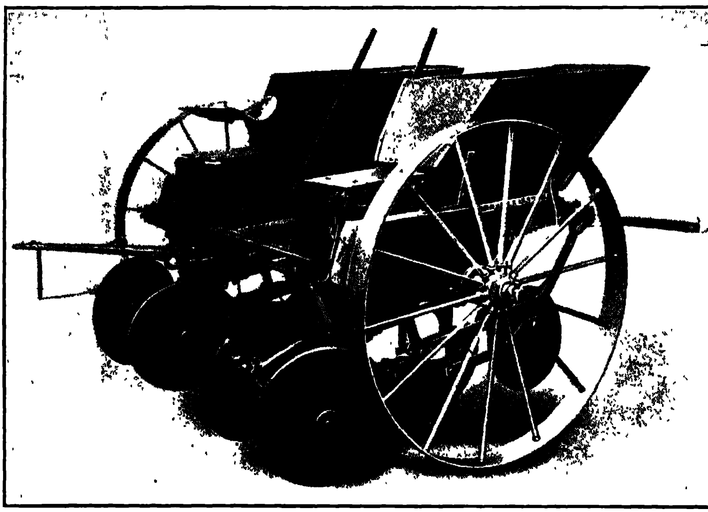
the seed; drop the seed to the bottom of this furrow at regular intervals, and cover the seed well. Provision must also be made for sowing fertilizer with the seed where it is required.

In order to accomplish these things under the many different conditions that exist, certain adjustments are necessary.

It must be possible to regulate the depth of planting, the

distance between seeds must be variable, to suit different field conditions; the distance between rows must be variable; a marker must be provided in order that the operator may plant in straight rows; and a fertilizer attachment must be combined with the planter.

Sizes.—Planters are built in both one-row and two-row sizes. The two-row machine accomplishes the work more rapidly. It



Courtesy of Eureka Mower Co.

FIG. 198.—One-man potato planter (two row).

also makes the use of a two-row cultivator more satisfactory, and this increases the rate at which the work of cultivating is done. The use of two-row planters, two-row cultivators, and even two-row diggers is increasing. Probably, within a few years, the use of these machines with tractors will become much more common in potato-raising districts.

This discussion will treat of the construction and repair of the one-row, one-man potato planter, as this is the size and type most widely used at the present time. The construction

of the two-row machine is practically identical with that of the one-row planter except that two planting units are provided instead of one (Fig. 198). The distance between these units may be changed so that the width between rows may be varied.

CONSTRUCTION AND PRINCIPAL PARTS

1. Main Frame (Fig. 199, *a*).—The main frame is usually made of heavy angle iron. It forms a support or point of attachment for all the other parts of the planter.

2. Main Axle (Fig. 199, *b*).—The main axle is a straight steel shaft about $1\frac{5}{8}$ ins. in diameter. It is a drive axle and transmits

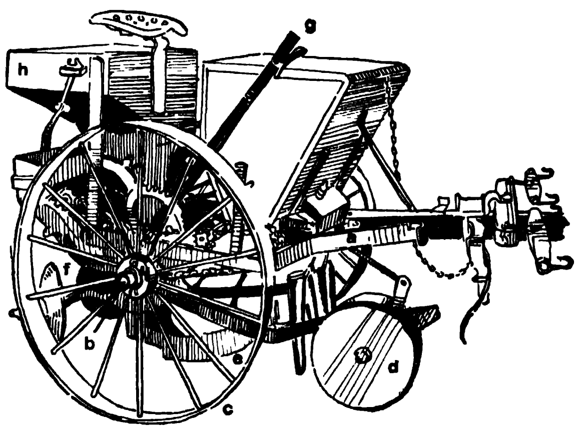


FIG. 199.—Principal parts of the potato planter.

power from the main wheels (Fig. 199, *c*) to all the working parts of the planter. It is hung from the main frame and is provided with bearings at either end.

3. Ratchet and Pawls.—The power of the main wheels is transmitted to the main axle by means of a ratchet and set of pawls in each wheel. In the planter shown in Fig. 199 the pawl holder is pinned to the axle, and the ratchet forms a part of

the hub of the wheel. The action of the pawls and ratchet has been thoroughly described in the chapters on drills and mowers.

4. Clutch.—The clutch is usually mounted on the main axle. The same type of clutch is used as on the grain binder. It consists of two parts, a sliding clutch operated by a spring, and a clutch sprocket which is free on the axle. Each of these parts carries notches which lock together when the clutch is engaged.

In the planter illustrated, a double clutch sprocket, which carries two chains, is used. One of these chains drives the potato-seed feeding device, and the other drives the fertilizer feed. The clutch is operated automatically by the action of a control lever. This lever (Fig. 199, *g*) lowers the furrow openers (Figs. 199, *d* and *e*) and covering attachment (Fig. 199, *f*). The setting of the control lever on the quadrant determines the depth of planting. The same movement of the lever that lowers the furrow openers also engages the clutch. Raising the furrow openers from the ground disengages the clutch.

5. Seeding Device. (Standard type.)

(*a*) *Hoppers.*—The potato seed is carried in the hopper shown in Fig. 200, *c*. The seed flows from this hopper to a lower hopper or magazine by gravity. The size of the opening between the upper and lower hoppers is usually adjustable. A liberal supply of seed must be present in the lower magazine.

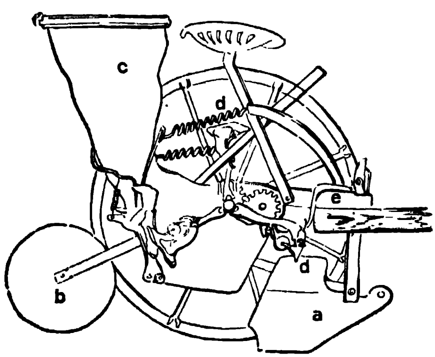


FIG. 200.—Cross-section of standard type of seeding mechanism.

(*b*) *Pickers.*—Several pickers (Fig. 201, *B*), mounted on a central shaft, revolve through the lower hopper or magazine. Each

picker spear (Fig. 201, *d*) picks up a piece of seed and carries it forward to the rear of the furrow opener (Fig. 200, *d*). At this point a stripper (Fig. 200, *e*) causes the seed to be pushed off the spear. It then drops to the bottom of the furrow.

The distance between seeds may be varied by changing the size of the sprockets which drive the picker shaft. In some planters it is easy to change the number of picker arms, and the rate of seeding may be regulated in this way.

Planters are commonly furnished with the necessary sprock-

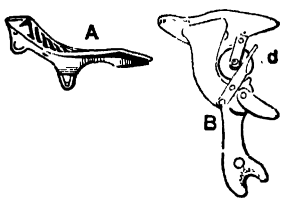


FIG. 201.—Detail of picker and concave.

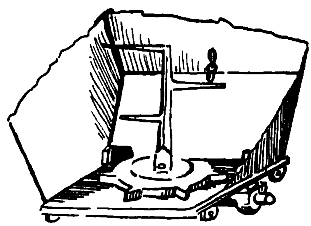


FIG. 202.—Fertilizer feeding device.

ets to plant seed at distances varying from about 10 to 20 ins.

6. Fertilizer Attachment.—A separate furrow opener (Fig. 199, *d*) is usually provided for the fertilizer attachment. Tubes, extending down from the fertilizer hopper, carry the fertilizer to the ground. The placement of these tubes is such that the fertilizer is mixed with the soil before it comes into contact with the seed. The front hopper, shown in Fig. 199, carries the fertilizer.

The fertilizer-feeding device (Fig. 202) is of the same type as that used in grain drills. The rate of feeding is regulated by changing the driving sprockets or by varying the size of the outlet from the hopper. Most planters are designed to sow any desired quantity of fertilizer per acre, from 300 to 3000 lbs.

The fertilizer-feeding attachment is driven by a chain from a sprocket on the main axle.

7. Furrow Openers (Figs. 199, *d* and *e* and 200, *a*).—The shoe type of furrow opener (Fig. 200, *a*) is commonly used.

Where a separate furrow opener is provided for the fertilizer, the double-disk type seems to be the most common. This leaves a ridge in the bottom of the seed furrow (Fig. 203, *A*) at the sides of which the fertilizer is deposited. The shoe furrow opener, which follows, splits this ridge as shown in Fig. 203, *C* and deposits the seed in the center. This prevents the seed from actually touching the fertilizer.

8. Covering Device (Fig. 200, *b*).—Covering disks are used on practically all makes of potato planters. They are placed at the rear of the planter. Their covering action is illustrated in Fig. 203, *D*. They are raised and lowered by means of the control lever (Fig. 199, *g*). Grease cups are provided for their lubrication.

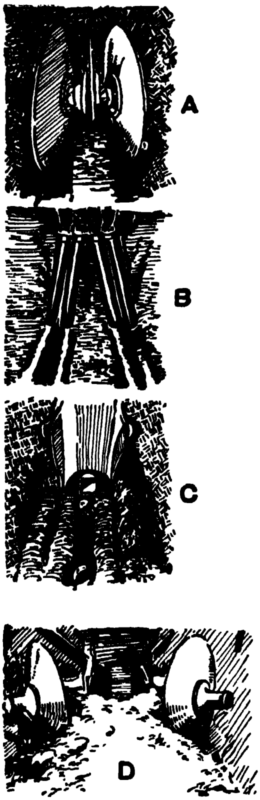


FIG. 203.—Action of furrow openers, fertilizer tubes and covering disks.

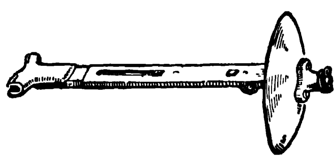


FIG. 204.—Disk Marker.

9. Marker.—Several types of markers are used, but all

have the same function. Figure 204 shows a disk marker. The marker is adjustable. It should be set so that the horizontal distance from the seed-furrow opener to the line made by the marker is the same as the distance desired between the rows. (Note that this setting differs from that of the corn-planter marker.)

10. Pole.—A long wooden pole is attached to the forward end of the main frame. Two-horse eveners are used with the single-row potato planter.

Tongue trucks are not commonly used, but a castor wheel may be obtained. This relieves the horses of neck weight.

LABORATORY STUDY NO. 17

To study the action of the various parts of the potato planter.

Equipment Necessary.—Complete potato planter. (With fertilizer attachment if fertilizer is commonly used in the region.)

Procedure.

1. Jack up the planter and support it securely, with the main wheels free from the floor.
2. Lower the furrow openers and covering disk.
   (*a*) Does this engage the clutch? If not, see that the clutch is engaged.
3. Turn one of the wheels and observe the action of the pickers.
   (*a*) How many pickers are used?
   (*b*) What means is provided for stripping the seed off the picker spears?
   (*c*) How is the rate of seeding (distance between seeds) changed?
   (*d*) How is the picker shaft lubricated?
   (*e*) List in order the parts that transmit power from the main axle to the picker shaft.
4. Examine the construction of the upper hopper and lower hopper (the lower hopper is sometimes called the magazine or picker pit).
   (*a*) What means is provided to insure a good flow of seed from the upper to the lower hopper?
5. List in order the parts that transmit power from the main axle to the fertilizer attachment.
   (*a*) What type of fertilizer feed is used?
   (*b*) How is the amount of fertilizer used per acre regulated?
   (*c*) What device is used to insure a free flow of fertilizer and to prevent plugging up?

6. Operate the control lever (or levers).

   (*a*) What type of furrow opener is used?
   (*b*) What type of covering device is used?
   (*c*) How is the covering device lubricated?

7. Examine the marker.

   (*a*) What type is used?
   (*b*) Change it from one side to the other.
   (*c*) How is it adjusted to give the desired distance between rows?

Job No. 29

TO OVERHAUL AND REPAIR A POTATO PLANTER

Operations Necessary to Perform the Job.

1. Clean out seed and fertilizer hoppers.
2. Jack up planter.
3. Loosen moving parts with kerosene.
4. Turn drive wheel and watch action of moving parts.
5. Replace worn parts and tighten loose bolts or rivets.
6. Clean out all oil holes.
7. Remove and clean grease cups and tubes.
8. Inspect chains.
9. Cover polished steel surfaces with grease.
10. Paint.
11. Lubricate all bearings.

Description of Operations.

1. Clean out the seed hopper, picker pit, and fertilizer hopper thoroughly.

2. Jack up the planter securely as in Laboratory Study No. 17.

3. Lubricate all bearings and oil holes liberally with kerosene, to loosen up rusty shafts or sprockets.

4. Lower the furrow opener. Turn one of the drive wheels and observe the action of all parts, watching for loose or worn bearings, sprockets, chains, etc. (This is a quick method of locating any part that is not functioning properly.)

5. Examine and test the condition of the parts listed below. These are all subject to rather rapid wear and require frequent replacement or adjustment.

(*a*) Pawls and pawl springs (tension of pawl springs may be increased temporarily by stretching).
(*b*) Main axle bearings.
(*c*) Clutch, clutch spring, clutch sprocket.

(*d*) Chains and sprockets.
(*e*) Picker shaft and bearings.
(*f*) Fertilizer attachment shafts and bearings.
(*g*) Picker arms (tighten all bolts or rivets).
(*h*) Picker spears and springs.
(*i*) Fertilizer-hopper agitator or belt.
(*j*) Seed-hopper agitator or belt.
(*k*) Furrow-opener and disk-coverer bearings.
(*l*) Marker blade (or disk) and all marker connections.
(*m*) Bolts attaching pole to main frame.

6. Clean out thoroughly all oil holes in all parts of the planter. A wire hook with a sharpened end is useful for this purpose.

7. Remove all grease cups and tubes. See that the grease flows through them freely.

8. Examine all chains and see that they are properly assembled. Replace worn links. Brush over the chains with an old paint brush dipped in oil.

9. Cover all polished steel surfaces with a thick coating of oil or grease.

10. Paint all parts that are liable to damage by rust. The seed and fertilizer hoppers in some planters are made of sheet iron. These should be well protected from rust.

11. Lubricate all the bearings thoroughly with oil or grease (as required) before considering the repair job complete.

LABORATORY STUDY NO. 18

To lubricate a potato planter and prepare it for field operation.

Equipment Necessary.—Complete planter, oil can, oil and grease, sharp-pointed wire, etc.

Procedure.

1. Locate all oil holes. Clean them out with the pointed wire, and oil thoroughly.
2. Refill and turn down all grease-cup caps several times.
3. Pack the disk bearings carefully with grease.
4. Rub oil on the sides of the concaves (Fig. 201, *A*) and partitions in the front of the picker pit. This prevents gumming up of the sides.
5. Examine the condition of the picker points and see that they are sharp.
6. Examine the stripper mechanism (parts that force the potato seed off the point) and see that it works properly.
7. Revolve the picker shaft slightly by hand to see that it turns freely.
8. Revolve the fertilizer-feed parts slightly by hand to make sure they are not stuck.
9. Operate the gate between seed hopper and picker pit to see that it does not bind.
10. Open and close the fertilizer-feed gate several times to free it from any hardened fertilizer.

JOB No. 30

TO OPERATE A POTATO PLANTER

Operations Necessary to Perform the Job.

1. Lubricate and prepare planter for the field.
2. Set position of picker points.
3. Adjust tension of concave springs.
4. Adjust hitch.
5. Fill seed and fertilizer hoppers. Have a supply of seed and fertilizer available.
6. Select proper sprocket to give desired distance between seeds.
7. Set fertilizer feed to give desired amount per acre.
8. Adjust marker to give desired distance between rows.
9. Begin planting by driving straight across one edge of field.
10. Regulate depth of planting.
11. Adjust covering device.
12. Check accuracy of planting.
13. Check rate of distribution of fertilizer.
14. Turn planter around, reverse the marker, and continue planting.

Description of Operations.

1. Lubricate and prepare the planter for the field. Full instructions for this operation are given on page 292.

2. The picker arms in some planters provide two places where the picker points may be attached. For small seed the point should be set in the hole nearest the end of the picker arm; for large seed it should be set in the hole farthest from the end of the picker arm.

3. At the rear of the planter in the bottom of the picker pit, flexible troughs are placed. These are called the concaves (Fig. 201, *A*). The picker points or spears pick up the potatoes from the groove or trough on the inner face of the concaves. Two of these concaves are usually provided, one for each set

of picker arms. They are flexible in order to accommodate themselves to the various sizes of seed. Their tension is adjustable by means of a spring and should be set so that they will hold the seed firmly against the pickers. These concaves are adjustable and may be set further back from the picker shaft, when planting large seed.

4. The height of the pole should be such that the planter frame and hoppers will be level when the machine is in operation. This adjustment is made by the neckyoke straps if horses are used. With tractors, adjustment is usually provided at the draw bar.

5. Fill the seed and fertilizer hoppers. A supply of seed and fertilizer should be kept in a wagon at one end of the field.

6. Select the proper sprocket to give the desired distance between seeds. The distance between seeds in the row is varied by changing the feed sprockets. Thirteen, 15, and 17 ins. are all standard distances. Planters are usually furnished with two sprockets, one that spaces the seed 13 ins. and one 15 ins. Sprockets for other distances are available.

7. Regulate the fertilizer feed to give the desired amount per acre. The fertilizer-feed settings are not usually marked on the potato planter as they are on the grain drill; consequently, it is difficult to get the desired rate of flow the first time. As the operator becomes familiar with his planter, however, and has an opportunity to check the amount of fertilizer used against the acreage covered, this adjustment will be more accurately controlled (see page 285).

Adjust to sow the desired quantity per acre, as described on page 285. The fertilizer delivery spouts or tubes should be set to spread the fertilizer along the sides of the seed furrow. Fertilizer should not be allowed to touch the potato seed. The fertilizer-feed wheels in some planters are equipped with "cut-off pins," or break pins. If an obstruction enters or parts become jammed, these pins shear off and so prevent more serious damage. If the flow of fertilizer stops, the cut-off pins should be inspected.

8. The adjustment of the marker determines the distance between rows. It should be set so that the distance from the center of the furrow opener to the mark is the desired distance between rows. In many potato-growing regions from 30 to 32 ins. is the standard distance.

9. Begin planting by driving straight across one edge of the field. Like other seeding machines, the potato planter is drawn back and forth across the field. On each trip the marker draws a line in the soil, on which the next row is to be planted. At the ends of the field the furrow opener and covering disks are raised while the machine is turned around. This disengages the clutch so that the working parts are idle when the machine is being turned around. The furrow opener should be lowered just after the planter is started across the field. It enters the ground more easily when the machine is in motion.

10. The depth of planting is controlled by the raising lever. When the desired depth setting is found the operator should set the lever in the same notch each time to secure uniform depth throughout the field.

On some planters an adjustment affecting the depth is also possible at the furrow openers.

11. The angle of the disks and the downward pressure on them are adjustable. Increasing the angle makes a higher ridge and throws the dirt in more. Sufficient penetration and angle should be given so that the seed is well covered and lightly ridged.

.12-13. Before making the return trip, check up on the rate of seeding and the rate of flow of fertilizer. This may be done by observing the amount of fertilizer used out of the hopper, and uncovering the row to note the distance between seeds.

Note.—The distance between seeds cannot be accurately tested by having the planter drop the seed on the surface of the ground, as the seed will bounce out of place. Uncovering the seed is the better way.

14. Raise the furrow opener, coverers, and marker, when the end of the field is reached.

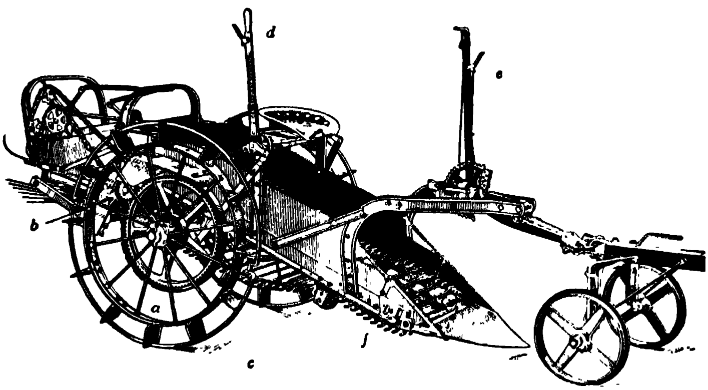
Turn the planter clear around and put it into position for the return trip across the field. The pole should be directly over the line made by the marker on the first trip. Swing the marker over to the opposite side of the planter and continue planting.

Note.—Some planters have an agitator in the bottom of the seed hopper. This stirs up the seed and causes it to flow down to the picker. Some planters have an adjustment controlling the movement of the agitator. This should be set so that an ample supply of seed is delivered to the picker pit. In some planters a feed gate is located between the seed hopper and the picker pit (also called magazine). This gate should be kept open wide enough to permit plenty of seed to enter the picker pit. If closed too much, the gateway may become clogged or "bridged over," thus cutting off the flow of seed to the magazine.

POTATO DIGGERS

Potato diggers, like all other farm implements, passed through many stages of development before the present standard type was designed. Various shapes of blades have been used for raising the potato out of the ground. Many devices have been tried for separating the potatoes from the accompanying mass of earth and vines.

The function of the modern digger, as indicated in the preceding paragraph, is to dig the potatoes from the ground, separate them thoroughly from the vines and soil, and drop them in rows or piles so that they may be easily gathered. To some extent, potato diggers have been equipped with picking attachments. With these the potatoes are deposited in piles or crates so that the work of gathering is much easier. Such attachments have been only partially successful and are not in general use.



Courtesy of International Harvester Co.

FIG. 205.—Standard type of elevator digger.

Types and Sizes.—The type of digger illustrated in Fig. 205 has come to be the standard. It is called the elevator digger. The size is determined by the width and length of the elevator (see arrows, Fig. 207, *a*). The elevators of the smaller machines

are usually 20 ins. in width and 5 to 6 ft. long. The larger machines, designed to be drawn by four horses or by a tractor, have 22-in. elevators, 6 or 7 ft. long.

The standard machine digs one row at a time. Two-row tractor diggers, operated by a "power take-off" from the tractor, are not yet in common use, but are being used to some

Courtesy of Hicksville Implement Co., Hicksville, N. Y.

FIG. 206.—Two-row tractor digger. (Note extension elevator, used in place of vine turner and shaker.)

extent in several potato-growing regions. A two-row tractor digger is shown in Fig. 206.

CONSTRUCTION AND PRINCIPAL PARTS

1. Main Frame (Fig. 207, *b*).—The main frame is made of two pieces of angle iron, one at each side of the digger. These are cross-tied with a short angle iron. The main frame supports the sideboards of the elevator (Fig. 207. *c*); and carries the brackets to which the shovel (Fig. 207, *d*) is attached. Two brackets are also carried at the rear of the main frame. The

main axle is held in these brackets, which are located toward the rear of the elevator. The digger beam is connected to the front end of the main frame (see Fig. 207, *e*). Various sprockets for the operation of the elevator chain links are also connected to the main frame.

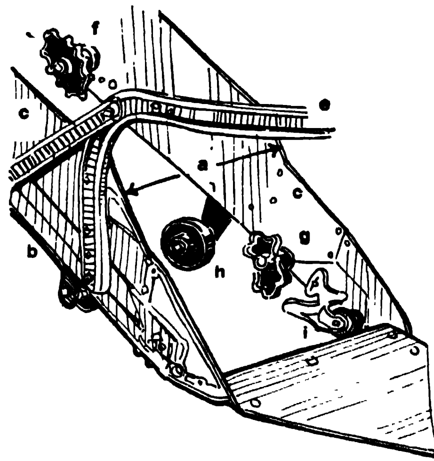


FIG. 207.—Detail of main frame, shovel, sideboards and beam.

2. Main Wheels (Fig. 205, *c*).—Both main wheels are drive wheels. They furnish the power for all the other moving parts. Large lugs (Fig. 205) are used to secure good traction. The steel ring is removed when the digger is at work. Steel wheels are used, varying in diameter on different diggers from 32 to 36 ins. The main axle is a fixed or "dead" axle, and the wheels revolve on it.

3. Ratchet and Pawls.—Power is transmitted from the wheels to the main drive gear (Fig. 205, *a*). Both chain-driven and gear-driven diggers are in common use. Figure 205 shows the main wheel and gear of a gear-driven digger. Small latches are placed in the main wheels of some diggers to engage and disengage the pawls. When the digger is being transported to the field the pawls are disengaged. This means of engaging the pawls serves as a clutch. In some diggers the action of the shaker lever (Fig. 205, *d*) or the shovel-lifting lever (Fig. 205, *e*) engages and disengages the pawls.

4. Main Drive Gear (Fig. 205, *a*).—One main drive gear is mounted on the main axle at each side of the digger. (Drive sprockets of similar size are used on chain-driven diggers.)

These gears act as pawl holders and transmit the power to the main drive pinion.

5. Main Drive Pinion (Fig. 205, *b*).—A main drive pinion is mounted on each end of the main drive shaft. This pinion meshes with the main drive gear and receives the power from it.

6. Main Drive Shaft.—The main drive shaft extends across the end of the digger underneath the rear of the elevator. All the working parts of the digger are driven from this shaft. Figure 208 shows the location of the main drive shaft and the sprockets that are keyed to it.

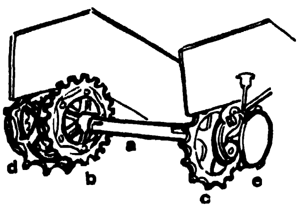


FIG. 208.—Main drive shaft and sprockets.

Figures 208, *b* and *c*, are the large sprockets that drive the elevator chain. These are keyed to the shaft so that they revolve just inside of the elevator sides. Figure 208, *d*, is the shaker-drive sprocket and Fig. 208, *e*, is the driving sprocket for the vine turner.

In brief, the main drive shaft has three distinct functions:

(*a*) Drives the elevator (Fig. 205, *f*).

(*b*) Drives the vine turner (Fig. 209, *b*).

(*c*) Drives the shaker (Fig. 209, *a*).

It is carried in brackets mounted under the main frame and is provided with renewable bearings, which are fitted with grease cups for lubrication.

7. Elevator (Fig. 205, *f*).—The elevators are made up of links of rod in the form of a chain. One-half of the elevator link rods are bent slightly upward and one-half are bent downward, the raised links alternating with the lowered ones. This forms pockets to carry the potatoes up the elevator and aids in separating them from the soil and vines.

The elevator is driven by the two large sprockets on the main drive shaft (Fig. 208, *b* and *c*). Each side of the elevator is provided with agitating sprockets, as shown in Fig. 207, *f* and *g*). As these sprockets revolve they "agitate" or shake the

elevator links, which aids in separating the potatoes from the vines. The under side of the elevator chain is supported by the roller shown in Fig. 207, *h*. This roller is used to take up the slack in the elevator. The lower end of the elevator is carried on the roller shown in Fig. 207, *i*. The bearings of all sprockets and rollers are renewable and must be frequently replaced. It is difficult to lubricate them successfully. They are covered with soil when the digger is in operation. Dirt and sand work into the bearing and cause rapid wear.

The elevator chain should be kept as tight as it can be hooked up by hand. If the chain becomes too slack it may climb on the driving sprockets or vegetation may wedge under it. Chain links must be removed when necessary to tighten the elevator chain.

8. Vine Turner (Fig. 209).—The vine-turner crank and forks (Fig. 209, *b*) act to separate the vines from the potatoes and soil. The action of the revolving forks frees the vines and turns them to one side with the aid of the vine-turner rods (Fig. 209, *c*). In this way the vines and trash are piled at the side of the row of potatoes. (The potatoes drop to the ground at the center of the rear of the digger.) This makes the work of picking them up much easier.

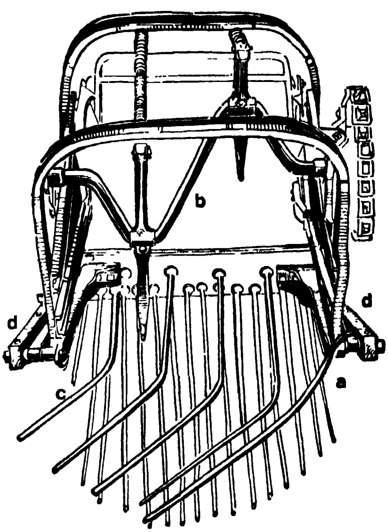


FIG. 209.—Vine turner and shaker.

9. Shaker (Fig. 209, *a*).—The potatoes pass up the elevator and are delivered to the vine-turner rods. Here the action of the forks frees the vines. The potatoes, and the soil that is mixed with them, drop through the wide-spread vine turner

bars (Fig. 209, *c*) onto the closely spaced bars of the shaker (Fig. 209, *a*). The shaker is mounted at the rear of the digger. It oscillates back and forth, sifting the soil through the bars and dropping the potatoes off the end of the bars.

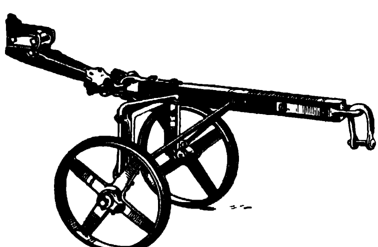
The shaker is suspended by hangers at the rear of the frame. It is given an oscillating motion by the pitmans (Fig. 209, *d*). One pitman is used on each side of the shaker. They are attached to crank wheels on the shaker crankshaft. This shaft is driven by a chain from the main drive shaft.

The shaker hangers and the pitmans are subject to rapid wear and should be well lubricated. They are always provided with renewable bearings, which need to be replaced frequently. The angle or downward pitch of the shaker is controlled by the lever (Fig. 205, *d*).[1]

10. Shovel (Fig. 207, *d*).—The shovel of the digger is made of highly tempered steel. It must be hard enough to scour well under many different soil conditions. It is bolted to the shovel brackets at the lower ends of the elevator sides.

The shovel is lowered into the working position by means of the shovel-lifting lever (Fig. 205, *e*).

It must penetrate deeply enough to get under all of the potatoes. If it is set deeper than necessary the draft is greatly increased. Regulation of the depth is controlled by the shovel-lifting lever which is attached to and operates the shovel-lifting beam (Fig. 207, *e*).



Courtesy of International Harvester Co.

FIG. 210.—Tongue truck.

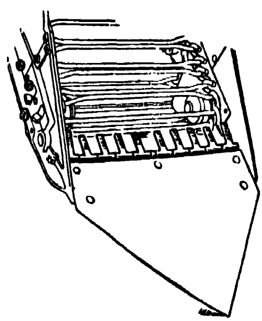
11. Tongue Truck (Fig. 210).—Potato diggers are regularly equipped with tongue trucks. The truck wheels support the weight of the

[1] On fields where the surface growth and vines are not heavy, the shaker and vine turner are frequently replaced by the extension elevator shown in Fig. 206.

front of the digger and make possible the convenient location and simple design of the lifting lever. The wheels are designed for the short turning usually necessary at the ends of the rows.

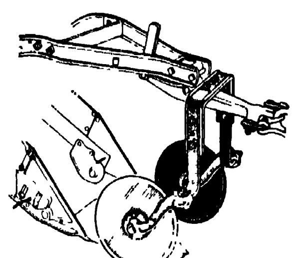
Figure 210 shows a tongue truck with a tractor hitch.

12. Stone Trap (Fig. 211).—The stone trap is a useful addition to the digger for use in stony fields. It is mounted between the lower end of the elevator and the shovel. A series of iron fingers prevent stones from lodging between the rear of the shovel and the lower end of the elevator.



Courtesy of International Harvester Co.

FIG. 211.—Stone trap.



Courtesy of International Harvester Co.

FIG. 212.—Rolling coulters.

13. Rolling Coulters (Fig. 212).—Rolling coulters may be used to good advantage on fields with a heavy growth of vines, grass, weeds, etc. Under such conditions, trouble is caused by the heavy surface growth lodging on the sides of the elevator and wedging in under the beam. A rolling coulter is mounted at each side of the shovel. If kept sharp, it cuts through the surface trash so that only the strip in front of the shovel is elevated.

LABORATORY STUDY NO. 19

To study the action of the various parts of the potato digger.

Equipment Necessary.—Complete potato digger.

Procedure.

1. Jack up the digger so that the rear wheels are free from the floor. Make sure that the jacks or blocks are so placed that they will not interfere with the working of any part. (With some diggers it is possible to slip a timber under the main frame, between the lower and upper side of the elevator chain. Then jack up on the ends of the timber.)

2. Engage the pawls by means of the latches in the main wheels. (This is done by lowering the shaker to working position on some machines.)

3. Revolve one rear wheel and observe the action of all parts.

   (*a*) List in order all parts transmitting power from the main wheels to the elevator.

   (*b*) List in order all parts transmitting power from the main wheel to the shaker.

   (*c*) List in order all parts transmitting power from the main wheel to the vine-turner crankshaft.

   (*d*) What is the ratio of the speed of the vine-turner crankshaft to that of the main wheel?

Job No. 31

TO OVERHAUL AND REPAIR A POTATO DIGGER

Operations Necessary to Perform the Job.

1. Sharpen shovel.
2. Repair and adjust elevator chain.
3. Replace bearings of elevator sprockets and rollers.
4. Replace worn pawls and springs in main wheels.
5. Test bearings of main drive shaft.
6. Inspect all chains and sprockets.
7. Test bearings of shaker and pitmans.
8. Adjust vine-turner forks.
9. Straighten rods of vine-turner and shaker.
10. Tighten lugs on main drive wheel.
11. Reassemble all parts and lubricate machine thoroughly.
12. Cover shovel with coating of grease or oil.

Description of Operations.

1. Remove and sharpen the shovel. This may be ground on the emery wheel or grindstone. Grind it on the same side that was originally ground. (Some manufacturers grind the upper and some the lower side.) Try to preserve the original bevel.

2. Unhook the elevator rod chain and remove it from the digger. Examine it carefully for worn or broken rods and replace any such. Straighten any that are bent.

3. Disassemble all of the rollers and agitator sprockets (Fig. 207, *f*, *g*, *h* and *i*). Wash all these parts clean in kerosene and test the bearings for wear. Replace the bearings if necessary.

4. Examine the pawls and pawl spring in the main wheels. Replace worn pawls and springs. Clean out oil tubes leading to the main-wheel bearings and wash the bearings thoroughly with kerosene.

5. Test the bearings of the main drive shaft. Some ma-

chines have plain bearings and some have roller bearings at this point. Clean out the grease tubes and bearings thoroughly. Put in new bearings if required.

6. Examine all chains and sprockets for wear. See that the chains are put on properly.

7. Test the shaker-hanger bearings and the pitman bearings (Fig. 209, *d*). These wear rapidly and need replacement nearly every season. In some machines the pitman bearings are adjustable so that the wear may be taken up.

8. Tighten the vine-turner forks (Fig. 209, *b*) so that there is no looseness between them and the shaft. To take up wear at this point it is often necessary to remove the fork and file off material from one-half of it. This allows the halves to draw tighter together.

9. Straighten any rods that may be bent in the vine turner or shaker.

10. Tighten the lugs on the main wheels (Fig. 205, *c*).

11. Reassemble all parts and lubricate the entire machine carefully.

12. Cover the shovel with a thick coating of grease or oil. This is a polished steel surface. If allowed to become rusty it will cause loss of time when the machine is in the field.

LABORATORY STUDY NO. 20

To prepare the potato digger for field operation.

Equipment Necessary.—Complete potato digger; oil, oil can, grease; sharp-pointed wire.

Procedure.

1. Locate all the grease cups. Refill and turn down the caps several times.
2. Locate all the oil holes. Clean them out thoroughly with a sharp-pointed wire. Oil each part thoroughly.
3. Oil the pawls and the latches (or lever) that operate them. See that they move freely.
4. Pull the elevator enough to be sure that it turns freely.
5. Revolve the vine-turning crank and operate the shaker to make sure they will function.
6. Tighten all lug bolts.

Job No. 32

TO OPERATE A POTATO DIGGER

Operations Necessary to Perform the Job.

1. Prepare digger for the field.
2. Adjust vine-turner crankshaft.
3. Adjust hitch.
4. Regulate setting of agitator sprockets and rollers.
5. Set elevator chain at proper tension.
6. Start digging at one edge of field.
7. Regulate depth of digging.
8. Adjust pitch of shaker.
9. Make return trip across field by digging third or fourth row (skip one or two rows).

Description of Operations.

1. The machine should be well lubricated and prepared for the field, as described in Laboratory Study No. 20, page 307.

2. Provision is usually made for changing the vertical distance between the vine-turner shaft and the shaker.

When it is necessary to set the shovel deep, and the vines are heavy, the vine-turner shaft should be set as far as possible away from the shaker. This gives more room for the passage of earth and vines. For light digging conditions, better work will result if this distance is decreased.

3. The draft of the potato digger is heavy. The larger size requires four horses or a tractor to draw it. Three horses may be used on the smaller size of standard elevator diggers, or, if the digging is not continued for long periods, two horses may handle the load.

Tongue trucks are used on the standard potato diggers. The wheels of the truck should set so as to be parallel with the pole. There is an adjustment provided for this purpose on the tongue truck.

Special four-horse eveners are furnished with the large-size diggers so that the horses walk between the rows.

4. The elevator rod chain should be kept at sufficient tension to operate properly. If too loose it may climb the sprockets, or it may sag down too much under a heavy load and the upper and lower sides may catch together. If the elevator is too tight the unnecessary tension increases the draft. The tension is regulated by removing or adding rod links to the elevator as required.

5. The elevator supporting rollers are adjustable and should be regulated to carry the slack on the under side properly. On some makes of diggers the height of the front end of the elevator above the shovel is adjustable by means of the two front rollers. The best results in stony ground are secured with the front end of the elevator raised as high as possible.

When separation is difficult and extreme agitation is needed on the elevator, the position of the large and small agitators may be reversed. With the large agitators in the lower position, the movement of the elevator is increased.

Only under unusual conditions should the above change be made. The least agitation that will give satisfactory separation should be used. In digging early potatoes particularly, the agitation given the elevator should be as little as possible. To lessen the agitation, a set of smooth rollers may be put on in place of one of the sets of agitating sprockets. An extra set of rollers is usually furnished with the digger for this purpose.

6. Start digging at one edge of the field. The shovel should be lowered while the machine is in motion. In some machines, lowering the shovel engages the pawls which drive the working parts. In others, lowering the shaker engages the pawls, while in some it is necessary to engage them by hand. This is done by means of small latches carried near the center of the main wheels. In any case, the elevator should be in motion before the shovel enters the ground.

Drive across the field, keeping the digger astraddle of the row.

7. The shovel should be lowered just enough to get under all the potatoes. The depth is regulated by the shovel-lifting lever (Fig. 205, *d*).

8. The pitch or downward slope of the shaker, under ordinary conditions, should be set so that the center bars just touch the ground. This adjustment will give the best rows of potatoes. If the potatoes are not well separated with this setting, the angle should be decreased or made less steep. Such a setting will give cleaner separation, but the potatoes will be scattered more.

Two holes are provided in the pitman cranks for setting the wrist pins which drive the shakers. One of these gives a greater

Courtesy of International Harvester Co.

FIG. 213.—Potato digger in action.

throw or movement to the shaker than the other. Under conditions where separation is difficult, the hole with the largest throw should be used.

9. Raise the shovel at the end of the row. Turn the digger around and make the return trip on the third row. One row is skipped at each end of the field. This method allows time for the men gathering the potatoes to pick up those in the first few rows. Then the digger returns and digs the rows that were skipped. In this way there is little chance of potatoes being injured by the horses or tractor (see Fig. 213). Where a large crew of pickers is employed, it is a common practice to dig every row, instead of alternate rows. This method is faster

and requires less travel of the digger, but extra pickers are required to keep the path of the digger clear of potatoes.

FIELD TROUBLES

The principal troubles met with in digging potatoes are caused by stones or by heavy surface growth of vines, grass, weeds, etc. It is difficult to remove this heavy surface growth by mowing and raking it off before digging, because of the ridges. In many cases, however, this can be done to advantage. When digging on such fields, the elevator should be given ample agitation and the vine-turner crank set high.

Stones are frequently a source of trouble. The stone trap mentioned on page 303 eliminates this difficulty to some extent. The elevator should be kept tight enough to prevent stones from working in between the sprockets (or rollers) and the rod links. The operator will find it convenient, when digging on stony fields, to have a short iron bar with which to pry up the elevator and release stones that become wedged in.

Hillside Operation.—Digging potatoes from fields on side hills is difficult. The digger slips downhill, and trouble is experienced in keeping it astraddle of the row. For this purpose, special lugs or spurs may be necessary. They are made so that one long face of each lug enters the ground in the best position to resist the side slipping and hold the digger to its work.

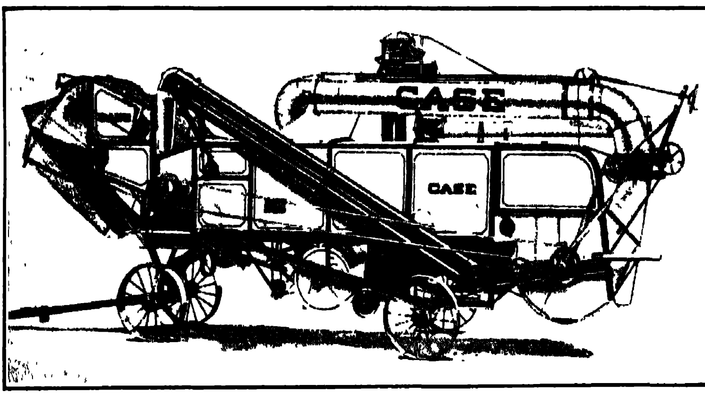
Some types of diggers are regularly supplied with a T-shaped lug. One face of this lug gives forward traction; the other resists side slipping.

A special lever for controlling the direction of travel of the tongue truck is supplied on some makes of diggers. This is a desirable feature and is particularly useful on hillsides.

CHAPTER X

THRESHING MACHINES

The stationary type of threshing machine is still the most widely used. The grain is hauled to it and the threshing is done with the machine "set" in one place. The straw is piled or stacked at the rear of the machine. The grain is either sacked at the machine or hauled away in large wagon



Courtesy of J. I. Case Threshing Machine Co.

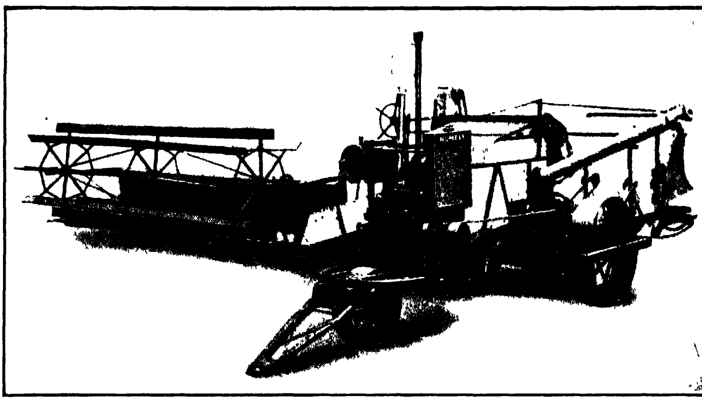
FIG. 214.—Modern type of thresher.

boxes. The thresher is mounted on a truck, so that it may be moved easily (Fig. 214).

During the last few years, machines have been developed that harvest and thresh the grain at the same time. These are called "combines," as they are a combination of the grain binder and the thresher. They are proving successful and will probably replace the present type of thresher to a large extent (Fig. 215).

The stationary type will be discussed here, for the reason that it is now in general use and will undoubtedly continue to be used for many years longer. If the student understands the principles underlying the construction and operation of threshers and has had experience with grain binders, he will be fairly well qualified to undertake the operation of a harvester-thresher combine.

Threshing machines are used for threshing all kinds of grain. They should thresh all the kernels from the head and



Courtesy of Advance Rumley Thresher Co., Inc.

FIG. 215.—Prairie type of harvester-thresher combine.

separate out all chaff, straw, weed seeds, etc. They are in reality grain-threshing and grain-cleaning machines. One part of the machine threshes, another cleans the threshed grain. The whole process is well described by the expression "separation"; hence these machines are commonly termed "grain separators."

Threshing machines are belt-driven. They must receive power from some outside source. Steam engines, gasoline or kerosene engines (farm tractors), and, in some districts, electric motors are used as sources of power.

Sizes.—The size of a threshing machine is expressed by stating the length of the cylinder (Fig. 218, *a*), which is at the front of the machine, and the width across the separating and cleaning parts, straw racks, sieves, etc., which are at the rear of the machine. These sizes are expressed in inches. A 20 x 36 grain separator has a cylinder 20 ins. long and a separating mechanism 36 ins. wide. This is considered a small machine and would require a farm tractor of about 18 belt horse power to operate it successfully. A 40 x 62 thresher with self-feeder and wind stacker is about the largest size made. This would require about 60 belt horse power for successful operation. The weight of the machines in the smaller size mentioned averages about 5000 lbs. Threshers 40 x 62 weigh approximately 10,000 lbs.

CONSTRUCTION AND PRINCIPAL PARTS

1. Feeder (Fig. 216).—The feeder conveys the bundles of grain into the machine. Large machines are always equipped with a feeder, the action of which is illustrated in Fig. 217.

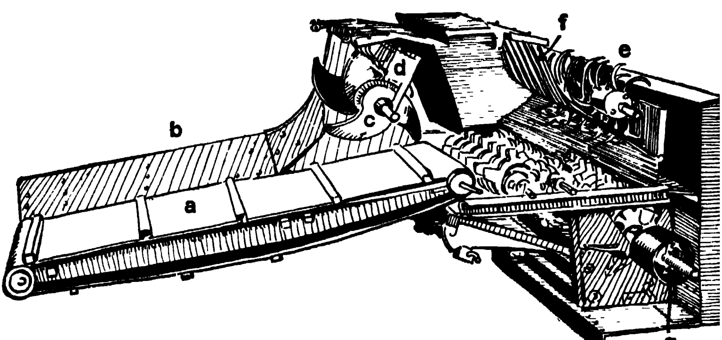


Fig. 216.—Construction and principal parts of feeder.

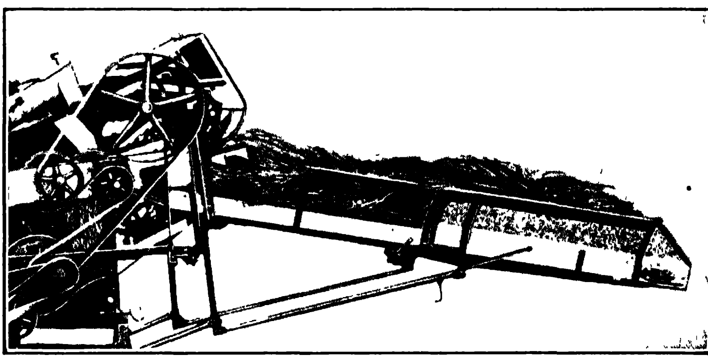
There are different types of feeders, but all are designed with the same objects in view. The function of the feeder is to cut the twine bands on the bundles and deliver the latter to the cylinder (Fig. 218) in a steady, even flow. All parts of

the cylinder should receive the same amount of straw, the outside ends as much as the center. In other words, the bundles should be spread out and fed evenly to all parts of the cylinder.

Figure 216 shows a sectional view of the various parts of a standard type of feeder.

(*a*) *Feeder Raddle or Conveyor Canvas* (Fig. 216, *a*).—This carries the bundles into the machine. It is equipped with sideboards (Fig. 216, *b*) which prevent the bundles from falling off. The bundles should be pitched on to the conveyor with the heads toward the cylinder.

(*b*) *Knives.*—The revolving knives (Fig. 216, *c*) cut the twine



Courtesy of Advance Rumley Thresher Co., Inc.

FIG. 217.—Action of feeder.

on the bundles and act to spread out and straighten the straw. The knives are kept clean and the straw is prevented from winding up on them by means of the stripping bars (Fig. 216, *d*) between which they revolve.

(*c*) *Spiked Roller.*—The spiked roller shown at Fig. 216, *e*, feeds the grain downward to the front of the cylinder. The bars (Fig. 216, *f*) prevent the spiked roller from clogging.

Many self-feeders are controlled by governors. If the rate of feeding becomes heavy enough materially to decrease the speed of the cylinder, the action of the governor automatically

stops the conveyor. No more bundles are fed in until the normal cylinder speed is regained.

Small threshers are not usually equipped with self-feeders. The bundles are cut and fed to the cylinder by hand.

2. Cylinder (Fig 218, *a*).—Threshing the kernels of grain from the heads is accomplished by the joint action of the cylinder teeth (Fig. 218, *a*) and the concave teeth (Fig. 218, *g*). The parts of the cylinder are as follows:

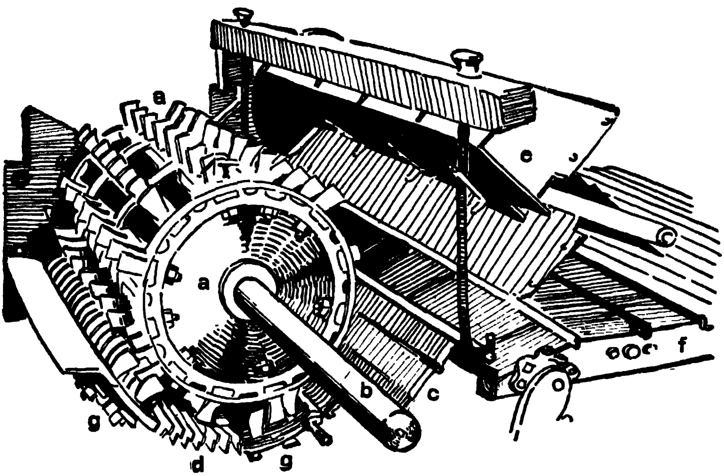


FIG. 218.—Construction of cylinder and concaves.

(*a*) *Cylinder Bars.*—The cylinder is made up of from nine to twenty parallel bars, each bar carrying a row of cylinder teeth (Fig. 218, *a*). Cylinder bars are usually made in two pieces.

(*b*) *Cylinder Teeth* (Fig. 218, *a*).—The cylinder teeth pass through the bar and are held with a nut and lock washer in the inside. They must be kept tight. A special wrench is furnished for this purpose.

(*c*) *Cylinder Shaft.*—The central shaft of the cylinder (Fig. 218, *b*) is large and heavy. It is made of a high-grade steel. It

is the main drive shaft and transmits power to all other parts of the machine. The main drive pulley (Fig. 216, *g*) is mounted on the cylinder shaft. This pulley is driven by a long belt from the source of power.

The speed of the cylinder is high. It varies from 750 to 1200 revolutions per minute in various sizes of machines. This gives a speed, at the circumference of the circle made by the cylinder teeth, somewhat greater than a mile per minute. If the speed becomes too high the kernels will be broken; if too low, they will not all be removed from the heads.

(*d*) *Cylinder Bearings.*—Because of its high speed and heavy load, the cylinder must have sturdy bearings, designed for easy and thorough lubrication. A babbitt-lined cylinder bearing with oiling device is commonly used. This bearing is provided with an oil ring which aids in distributing oil to the entire surface of the bearing.

Ball bearings are also used on the cylinder shaft. The balls are packed in grease and enclosed in a dust-proof housing. A grease cup is also provided for additional lubrication.

A special grade of heat-resisting lubricant is required for the cylinder bearings.

3. Concaves.—The concaves are flat bars of iron which extend across the machine just below the cylinder. They are so called because the bars are slightly concave to correspond to the shape of the cylinder, which revolves above them. Figure 218, *g*, shows the location of the concaves. Each concave carries two rows of teeth, which are driven into the concave and secured with a nut on the under side, as shown in Fig. 219, *B*. The concaves are stationary. The cylinder teeth revolve between the concave teeth, as illustrated in Fig. 219. In this figure the concaves are correctly adjusted. It is often found that the concaves are too far

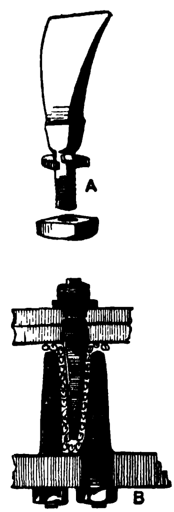


FIG. 219.—Detail of concave and cylinder teeth.

away from the cylinder teeth. With such a setting, whole heads of grain might pass through unthreshed.

The adjustment which regulates this setting is shown in Fig. 220. The concaves are held in place by hangers and may all be adjusted as a unit. Adjustments are also provided for moving either the concave or the cylinder sidewise. The setting of this adjustment will correct such a condition as that just mentioned. The cylinder teeth should pass through the center of the space between the concave teeth.

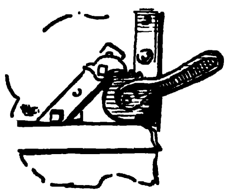


Fig. 220.—Adjustment for setting concaves.

The number of concaves to use depends upon the kind and condition of the grain being threshed. One concave is generally used for threshing oats under ordinary conditions. As many as three concaves (six rows of teeth) may be necessary for difficult threshing, such as flax that is not well dried. The rule should be to use the smallest number of concaves that will thresh all the kernels from the heads. Each additional row of concave teeth adds to the load and consumes more power.

4. Grates (Fig. 218, *c*).—The grate extends upward at the rear of the cylinder. Grates that are interchangeable with the concaves are also used. These are called concave grates (Fig. 218, *d*). When a concave is removed a concave grate is put in its place. The proper placement and arrangement of the concaves and grates will be discussed on page 337.

Separation of the grain from the straw is largely accomplished at the rear of the cylinder, by means of the grates. The kernels of grain sift through the grates and drop to the grain pan (Fig. 222, *a*). The straw cannot pass through the narrow bars of the grates; it is directed up the grate and back to the straw rack (Fig. 221) by the action of the cylinder and the beater (Fig. 218, *e*).

5. Beater.—The location of the beater is shown in Fig. 218, *e*. As the beater revolves it directs the straw downward to the straw rack (Fig. 221). It prevents the straw from

winding on the cylinder and tends to spread it so as to cover the full width of the straw rack.

6. Straw Rack (Fig. 221).—The location of the straw rack is indicated in Fig. 218, *f*. Its function is to convey the straw to the rear of the machine and to shake or agitate it so as to sep-

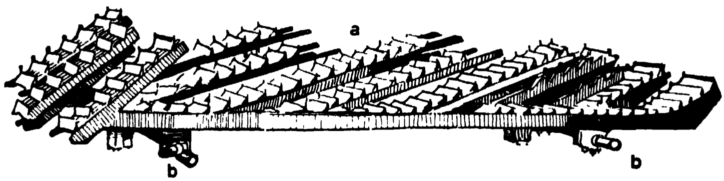


FIG. 221.—Straw rack.

arate all the grain. To accomplish this, straw racks are given an oscillating motion by means of the crankshafts shown in Fig. 221, *b*.

The notched fingers, called "fish backs," on the straw rack throw the grain backward, gradually working it to the rear of the machine. This thorough shaking up of the straw sepa-

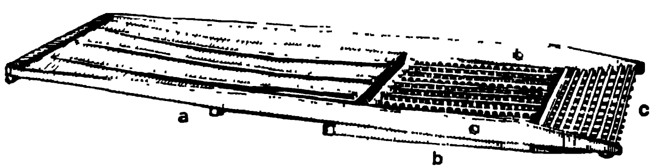


FIG. 222.—Grain pan, chaffer and chaffer extension.

rates all the grain from it. The grain falls through the open spaces in the straw rack to the grain pan (Fig. 222).

7. Grain Pan and Chaffer (Fig. 222).—The grain pan is located directly below the straw rack. It extends from the front of the cylinder well toward the rear of the machine. As the grain is threshed out by the cylinder and is further separated by the action of the grates and straw rack, it falls to the grain pan (Fig. 222, *a*). The motion of the grain pan is balanced

with that of the straw rack. The straw rack has longer lever arms and consequently it oscillates through a longer stroke than the grain pan. When both are loaded they will be more accurately balanced than when the machine is empty.

The motion of the grain pan works the grain backward. The rear of the grain pan has an adjustable sieve, called the "chaffer" (Fig. 222, *b*). The chaffer has large openings which allow all but the coarse straw or unthreshed heads of grain to drop through it and down to the sieves of the cleaning mechanism (Fig. 223).

8. Chaffer Extension (Fig. 222, *c*).—The chaffer extension is a short, adjustable sieve with large openings. Its function is to carry straw or coarse chaff from the grain pan and chaffer back to the stacker. Some straw and chaff always sift through the openings in the straw rack and drop to the grain pan with the grain. The chaffer and chaffer extension should carry this back to the stacker, but should allow any grain to drop through the openings provided (Figs. 222, *b* and *c*).

Many unthreshed heads and kernels of grain, mixed with chaff, reach the chaffer extension. The openings in this should be adjusted to a size large enough to allow such material to pass through, so that it will not be carried out with the straw.

9. Tailings Auger and Tailings Elevator.—The tailings auger (Fig. 223, *a*) is placed directly below the chaffer extension. Unthreshed kernels and chaff drop through the openings of the chaffer extension into this auger or conveyor. The tailings auger carries the chaff and unthreshed grain to the tailings elevator, which returns it to the cylinder for rethreshing.

The tailings auger and elevator thus provide a means for running the tough heads of grain through the machine twice. This saves a great deal of grain that would otherwise be lost in the straw.

10. Cleaning Device, or Fanning Mill (Fig. 223).—The cleaning device, or fanning mill, cleans the grain from the light chaff, weed seeds, etc. It consists of three main parts: the shoe, the sieves, and the fan.

(*a*) *Shoe.*—The location of the shoe is shown in Fig. 223, *b*. The shoe is given a shaking motion by means of a pitman. This causes the kernels of grain to be shaken through the sieves which are mounted above the shoe.

(*b*) *Sieves.*—Adjustable sieves, such as the one shown in Fig. 223, *c*, are the type commonly used in modern threshers. The size of the opening is adjustable, so that the same sieve may be used for various kinds of grain.

The grain sifts through the holes in the sieve and drops down to the inclined bottom of the shoe. It slides down the bottom of the shoe (which is constantly shaken back and forth by the pitmans), into the grain auger or conveyor (Fig. 223, *d*). This

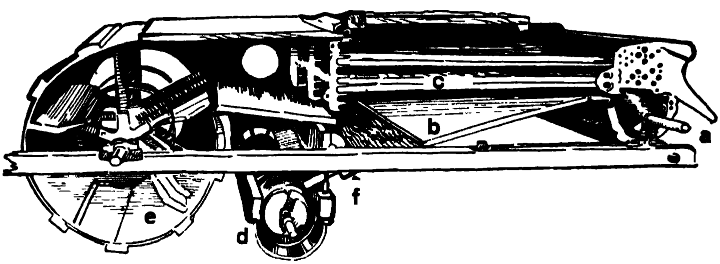


FIG. 223.—Cleaning Device.

extends across the bottom of the shoe and carries the grain to the place where it is put into bags or wagon boxes, as will be explained later.

(*c*) *Fan.*—The fan is located as shown in Fig. 223, *e*. It extends across the entire width of the machine, so that it directs an equal draft of air through all parts of the shoe. This draft of air plays against the under side of the shoe sieves (Fig. 223, *c*), the chaffer (Fig. 222, *b*), and the chaffer extension (Fig. 222, *c*). It blows the light straw and chaff into the stacker, but the heavier grain sifts through the sieves and slides down the inclined sieve to the grain auger.

Chaff, straw, and unthreshed heads of grains that reach the shoe sieve (Fig. 223, *c*) are blown off the rear end of the sieve

into the tailings auger (Fig. 223, *a*) and returned to the cylinder for rethreshing.

Under certain conditions it is necessary to use a weed screen (Fig. 223, *f*) in the bottom of the shoe. This allows the small weed seeds to pass through and drop to the ground. The grain kernels, being larger, cannot pass through the openings in the weed screen, but slide over it to the grain auger (Fig. 223, *d*).

Good threshing demands careful adjustment of the cleaning device. The amount of air used through the shoe, the size of the openings in the shoe sieve and chaffer, the angle of the chaffer extension, etc., are all adjustable. Directions for making these adjustments are given in Job. No. 35.

11. Straw Stacker (Fig. 224).—Two types of straw stackers are in common use, the straw carrier and the wind stacker.

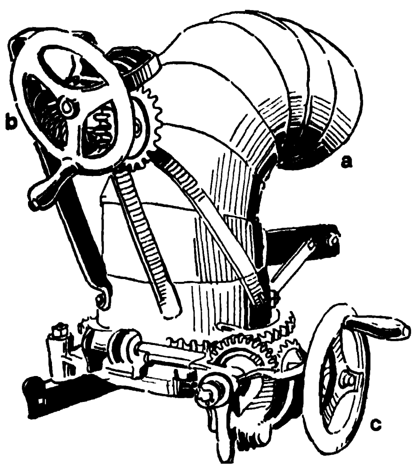


Fig. 224.—Straw stacker or blower.

The straw carrier is much the same in general construction as the web carrier used on the self-feeder (Fig. 216, *a*). It elevates or carries the straw away from the machine. Straw carriers are used on the smaller sizes of threshers.

Wind stackers are used on the larger-size threshers. They are sometimes referred to as "blowers." They consist of a large fan (Fig. 225) and a large adjustable pipe (Fig. 224, *a*). The end of the pipe is fitted with an adjustable hood. The fan is mounted inside of the housing shown in Fig. 226.

Wind stackers are provided with adjusting cranks for

raising or lowering the pipe and for swinging it from side to side.

Figure 224, *b*, shows the hoisting crank, and Fig. 224, *c*, the swinging or oscillating crank. When not in use, the wind stacker may be folded back over the thresher, as illustrated in Fig. 214. By means of these cranks a very large stack of straw may be made without changing the position of the thresher.

12. Grain-handling Device (Fig. 227).—The threshed and cleaned grain slides down the inclined bottom of the shoe to the

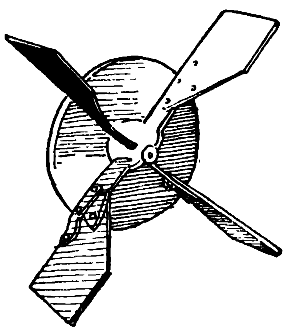


FIG. 225.—Straw stacker fan.

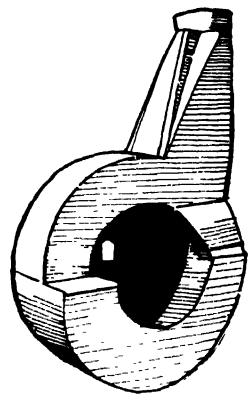


FIG. 226. —Fan housing.

grain auger. This carries it across the machine. On small threshers it is caught in baskets at this point. On larger machines, however, which thresh out the grain very fast, this process would be too laborious. Hence, grain-handling devices are used, so that very little labor is required to handle the threshed grain.

A commonly used grain-handling device consists of an elevator (Fig. 227) on the inside of which a chain, with cup-like receptables, carries the grain upward to the weigher. The weigher is a metal basket that dumps itself automatically when a certain weight of grain has entered. The weigher basket

is provided with a scale and may be adjusted so that it dumps when exactly the proper weight has entered it. This weight will, of course, vary for the different kinds of grain; hence, the careful adjustment of the weigher is necessary. Each time the weigher trips it registers on a meter, so that the number of bushels threshed is automatically recorded.

Courtesy of Advance Rumely Thresher Co., Inc.

FIG. 227.—Grain handling device.

When the weigher dumps, its load is delivered to the bagger spouts, at the bottom of which means for holding two bags are provided. Two are necessary in order that one may be filled while the other is being taken off, tied, and placed on the wagon (Fig. 227).

Grain spouts for loading the grain loose in wagons are often used instead of baggers.

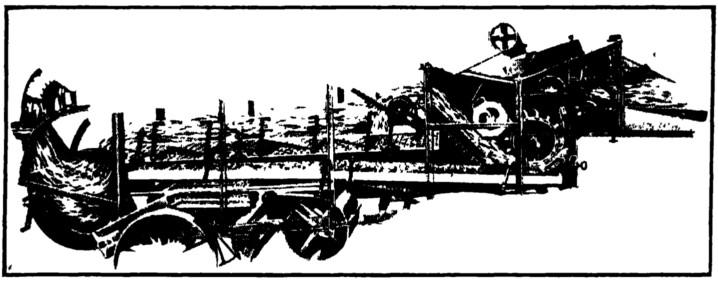
LABORATORY STUDY NO. 21

To name and locate the various parts and trace the course of the grain and straw through the threshing machine.

Equipment Necessary.—Complete thresher.

Procedure.—(Refer to Fig. 228.)

1. Locate the feeder. (A self-feeder or merely a feeding table may be used.)



Courtesy of Advance Rumely Thresher Co., Inc.

FIG. 228.—Showing course of the grain through the thresher.

(*a*) How is the grain carried into the cylinder?
(*b*) What means is provided for cutting the twine bands on the bundles?
(*c*) What drives the feeder raddle or carrier (if any is used)?
(*d*) What is the purpose of the sideboards on the self-feeder (if used)?
(*e*) Is the feeder provided with a governor?
(*f*) What means or device is provided to feed the grain evenly to the cylinder?

2. Examine the cylinder and answer the following questions:

(*a*) What type of bearings are used for the cylinder shaft, and how may they be adjusted?

(*b*) Is there an adjustment for taking up "end play" of the cylinder?
(*c*) How many bars are used in the cylinder, and how many teeth in each bar?
(*d*) Test all the cylinder teeth to determine if any are loose. (Rap each one with a hammer.)

3. Revolve the cylinder and see that the cylinder teeth pass through the center of the space between the concave teeth (see Fig. 219, *B*).

4. Locate the concaves and the adjustment for them (See Fig. 220).

(*a*) Test all concave teeth to make sure that all are tight.
(*b*) Adjust the concaves as close as possible to the cylinder; then adjust them as far as possible from the cylinder; then return them to their proper position (Fig. 219, *B*).
(*c*) How many concaves may be used in this machine?
(*d*) How may an additional concave be put in place of the concave grates (Fig. 218, *d*).

5. Locate and explain the purpose of the straw grate (Fig. 218, *c*). The doors on top of the machine must be opened in order to see the remaining parts.

(*a*) Where does the major part of the work of separating the grain from the straw take place?

6. Revolve the beater and notice its direction of rotation.

(*a*) What is the purpose of the beater?

7. Examine the straw rack through the open doors at the top of the machine. Revolve the pulley that drives the straw rack and watch its action.

(*a*) What is the purpose of the straw rack?
(*b*) Why is it given this peculiar jerky motion?
(*c*) For what purpose are the open spaces in the bottom of the straw rack?

8. Revolve the pulley that drives the grain pan and observe its motion.

(*a*) Locate the pitman that drives the grain pan.
(*b*) Is this pitman adjustable?
(*c*) How many hangers are provided for this grain pan?
(*d*) What is the function of the grain pan?
(*e*) Whence does it receive the grain?

9. Locate and notice the movement of the chaffer (see Fig. 222, *b*).

(*a*) Are the openings in the chaffer adjustable?
(*b*) What is its function?
(*c*) Where does the grain go that sifts through the openings in the chaffer?
(*d*) What effect does the blast of air from the fan have on the action of the chaffer?

10. Examine the position and movement of the chaffer extension.

(*a*) What is its function?
(*b*) What is the course of the unthreshed grain or parts of grain heads that sift through the large openings in the chaffer extension?
(*c*) Why should the openings in the chaffer extension be larger that those in the chaffer?

11. Revolve the tailings auger in its proper direction of rotation and notice its motion.

(*a*) What is the purpose of this auger?
(*b*) Whence does it receive a supply of chaff or unthreshed heads of grain?

12. Examine the construction and note the action of the tailings elevator.

(*a*) What is the function of this elevator?
(*b*) How are the elevator cups or carriers driven?

13. Locate and notice the movement of all parts of the grain-cleaning device.

(*a*) Are adjustable sieves used?
(*b*) How many sieves are used?
(*c*) Is the shaking motion of the shoe lengthwise of the thresher or crosswise?
(*d*) How is the fan driven?
(*e*) How may the amount of air used be adjusted?
(*f*) Is there a place for a weed screen in this shoe?

14. Examine the stacker or straw carrier.

(*a*) Locate all the adjustments used in forming the stack of straw.
(*b*) Locate the fan (if a wind stacker is used).
(*c*) Are the fan-shaft bearings adjustable?

15. Locate the grain auger and notice its action.
(*a*) What is the function of this auger?
(*b*) How is it driven?

16. Locate the weigher (if used) and all of its various parts, as follows:

(*a*) Elevators.
(*b*) Weigher basket.
(*c*) Tripping device and meter.
(*d*) Bagger or grain spouts.

17. Trace the course of the grain through the machine, naming every part through which it passes.

18. Trace the course of the straw through the machine, naming every part through which it passes.

Job. No. 33

TO OVERHAUL AND REPAIR A THRESHING MACHINE

Operations Necessary to Perform the Job.

1. Repair feeder carrier.
2. Sharpen band knives.
3. Clean and adjust cylinder-shaft bearings.
4. Replace worn cylinder teeth.
5. Take up end play in cylinder shaft.
6. Replace worn concave teeth.
7. Adjust bearings of rocker arms or hangers of straw rack.
8. Adjust bearings of straw-rack cranks.
9. Adjust bearing of pitman used to drive straw rack and grain pan.
10. Repair grain pan and adjust hangers.
11. Inspect chaffer and chaffer extension.
12. Inspect and adjust all parts of cleaning device or fanning mill.
13. Repair and adjust grain auger and tailings auger.
14. Remove and repair tailings elevator.
15. Remove and repair grain elevator; inspect and test weigher; examine grain spouts and bagger.
16. Repair wind stacker (or straw carrier, if used).
17. Lubricate all bearings thoroughly.

Description of Operations.

1. Replace broken slats in the feeder carrier. See that the canvas is properly attached to the slats and that the leather straps (if used) are in good condition. Replace feeder sideboards if necessary.

2. Sharpen the band knives (Fig. 216, *c*) and replace any that are broken.

3. Clean and adjust the cylinder-shaft bearings. Provide new bearings if necessary. See that the grease tubes leading to these bearings are clear.

4. Replace worn cylinder teeth. This must be done about every season if the thresher is used for custom work. Worn

cylinder and concave teeth make the load heavier and cause a loss of power. When new teeth are put in it is necessary to drive them in firmly with a hammer and then tighten the nuts. All the teeth should be gone over with a heavy hammer several times. Each time they may be drawn a little tighter. It is possible to detect a loose tooth by the sound it gives when struck with a hammer.

5. Take the " end play " out of the cylinder. A special adjustment is usually provided for this purpose, near one of the cylinder-shaft bearings.

6. Replace broken or worn concave teeth. To do this the concaves are removed from the machine. Tap the new teeth down well with the hammer, and tighten several times. The concave teeth should not be struck as heavy blows with the hammer, when tightening, as the cylinder teeth. The concaves are cast iron and are liable to break. The bars of the cylinders are steel.

7. Take up the bearings between the studs and rocker arms that drive the straw rack. These rocker arms serve as hangers for the straw rack. They may be seen in Fig. 228.

8. Examine the bearings of the straw-rack cranks (Fig. 221, *b*) and take up any wear or looseness. See that the oil passages leading to these parts are open.

9. Adjust the bearings of the pitman that drives the straw rack. These bearings are usually adjustable with set screws or bolts. If two pitmans are used they must be kept exactly the same length.

10. Move the grain pan back and forth and see that it works freely. Examine the bottom and sides, and replace any broken sections. Canvas or wood guides are provided between the stationary sides of the thresher frame and the moving grain pan. These should be gone over carefully and tightened or replaced as required, to prevent grain from leaking out.

Adjust the bearings of the grain-pan hangers, or put in new hangers if they are badly worn. The hangers must be adjusted equally on both sides so that the grain pan will hang level.

11. Inspect the chaffer and chaffer extension. See that all parts of these are in good condition. Tighten the connections holding the chaffer to the grain pan.

12. Examine all parts of the cleaning device.

(a) See that the screen adjusters work freely.

(b) Test the bearings of the shoe pitmans and adjust them properly. (Both shoe pitmans must be of equal length.)

(c) Repair the sieves and sieve frames as required. The frames must be straight, the corners tight, and the metal of the sieves free from breaks or tears.

(d) Adjust the fan bearings to take up the wear. (Remove shims as required.)

(e) Examine the fan blades. Replace any that are broken. Tighten the rivets or put new rivets into blades that are loose. See that the fan blades revolve without striking.

13. Revolve the grain auger and tailings auger to see that they turn freely.

(a) Examine the troughs that surround these augers. These troughs are made of sheet iron and should be protected from rust.

14. The tailings elevator or carrier may be made of steel cups or small wooden slats, mounted on a long chain or web. This may be disconnected so that the entire elevator may be pulled out for inspection. Broken cups or slats should be replaced. The bearings for the shafts at the top and bottom of the tailings elevator should be adjusted. Then the carrier may be replaced and drawn up tight enough to prevent slippage.

15. Test the grain elevator and adjust the bearings at the upper and lower ends, as required. Examine the chains and cups of the grain elevator. Test the weigher basket and see that it trips properly. Straighten the grain spouts and bagger parts, as required.

16. Adjust the bearings on the end of the shaft of the wind stacker to take up looseness. (This may be done by removing shims.)

(*a*) Test the fan blades and spiders of the wind-stacker fan in the same manner as the grain-cleaning fan. Revolve the fan and see that none of the blades strike.

The fan blades must be of equal length and equal weight in order that the fan may balance properly. If one side (or blade) is heavier than the other, it will not run properly at high speed.

To balance the fan, practically the same method may be followed as will be described in Job No. 34, page 333. (Balancing the Cylinder.)

(*b*) Examine the lifting and swinging adjustments (Figs. 224, *b* and *c*) on the wind stacker, and see that they function properly.

(*c*) Straw carriers frequently require new sideboards and bottomboards. In addition, the following will need careful attention and adjustment.

(1) Carrier slats.
(2) Carrier rollers and the bearings of such rollers.
(3) Elevating or raising mechanism for the straw carrier.

17. Lubricate thoroughly all bearings in all parts of the thresher. A sharp wire hook will be useful in this work for cleaning out oil holes. All grease cups should be filled and carefully turned down.

The axles of the truck wheels must also be greased.

Job No. 34

TO REPAIR AND BALANCE THE CYLINDER

Operations Necessary to Perform the Job.

1. Remove cylinder.
2. Support ends of cylinder shaft on two saw-horses.
3. Put in new cylinder teeth as required.
4. Set up two steel " straight-edges " on saw-horses.
5. Level saw-horses in both directions.
6. Place ends of cylinder shaft on steel straight-edges.
7. Test the cylinder for light spots and add wedges as required.

Description of Operations.

1. Remove the cylinder from the machine.

2. Support the ends of the cylinder shaft on two saw-horses.

3. Replace the cylinder teeth as described in Job No. 33. Tighten the new teeth securely. The cylinder teeth that pass through the bands around the cylinder are longer than the others. These are called band teeth.

4. Fasten two flat pieces of steel or smooth iron (about $\frac{1}{4}$ in. by 2 ins. by 12 ins.) to the saw-horses, with the edges up. (Carpenters' squares may be used for this purpose.)

These must be secured with blocks.

5. Level the saw-horses accurately in both directions.

6. Place the cylinder-shaft ends on these pieces of steel.

7. Roll the cylinder easily along the pieces of steel. When it comes to rest, mark the cylinder bar that is uppermost with a piece of chalk.

Roll the cylinder again. If it comes to rest with the chalk mark up again, this part of the cylinder is light. Drive a wedge under the center band.

Rub off the chalk mark and repeat this process until the cylinder comes to rest at any point. (No light spots are indicated unless it always comes to rest at the same point.)

Follow the same method for balancing the wind-stacker fan. (Weights may be added to the fan blades in the form of washers or nuts, as required.)

Note.—It is necessary to have the cylinder well balanced. It runs very fast. Any unevenness in weight is particularly noticeable at high speeds and very hard on the bearings of the cylinder shaft.

LABORATORY STUDY NO. 22

To lubricate all parts of a threshing machine.

Equipment Necessary.—Complete thresher; oil and grease, oil cans; sharp wire; cotton waste.

Procedure.

1. Locate all grease cups or oil holes on the feeder. Clean out the oil holes and oil each one thoroughly. Refill all the grease-cup caps and turn them down several times. Count the number of places to be lubricated on the feeder.

2. Remove the grease-cup caps on the cylinder bearings. Refill and turn them down several times. (Some cylinder bearings have oil cups instead of grease cups. Fill these with oil.) The cylinder bearings require a high-grade lubricant. Do not use cheap axle grease on them.

3. Grease or oil all shafts, cranks, or bearings on the left side of the thresher. Count each place and remember how many places there are to be oiled.

4. Grease or oil all places on the right side of the thresher. Remember the number of places to be oiled. Can these places be oiled when the machine is in operation?

5. Lubricate all parts on the straw stacker, including the raising and oscillating cranks.

6. Oil lightly the parts of the tripping mechanism of the weigher and meter.

7. Grease the axles of the truck.

8. Keep the supply of oil and grease, that is carried with the thresher, free from dust and chaff.

Job No. 35

TO OPERATE A THRESHING MACHINE

Operations Necessary to Perform the Job.

1. Level machine.
2. Block wheels.
3. Put in proper number of concaves and adjust sieves.
4. Align tractor or driving motor with thresher and put on drive belt.
5. Run cylinder idle before putting on any of the thresher belts.
6. Put on all thresher belts and run machine slowly for a few minutes.
7. Lubricate all parts while machine is running.
8. Increase speed until cylinder is running at its rated speed.
9. Feed in grain.
10. Lubricate all parts frequently.
11. Make adjustments necessary to save all grain and to clean it well.

Description of Operations.

1. Set the thresher so that it is level both lengthwise and crosswise. If the machine is low in the front the grain will pile up on the grain pan and not move backward to the sieves.

2. Block the wheels to prevent the machine from being drawn forward by the belt.

3. Make the concave and sieve adjustment suitable for the grain to be threshed according to the following directions.

The number of concaves used depends upon the kind and condition of the grain. The rule is to use as few rows of teeth as possible and still secure thorough threshing. Set the concaves close enough to prevent the grainheads from passing through unthreshed.

If too many rows of concave teeth are used, or if they are set too close, the straw will be chopped up very fine. This will tend to overload the cleaning sieves or clog them up. It is very difficult to secure well-cleaned grain under such conditions.

The following directions apply to the threshing of the common grains under average conditions.

Wheat.

(*a*) Four rows of teeth (two concaves) are usually required.

(*b*) A blank concave (with no teeth) or a concave grate may be placed between the two filled concaves (see Fig. 128, *d*).

(*c*) Cylinder should be running at rated speed.

(*d*) The chaffer sieve, chaffer extension sieve, and shoe sieve should be adjusted while the machine is running, until best results are secured. When the straw is very dry, the cylinder speed may be slightly reduced to prevent the breaking and chopping up of the brittle straw. For grain in such a condtion, a heavy blast of air must be used on the shoe sieve to blow off the chaff.

Oats.

(*a*) Dry oats may be well threshed out of the heads with two rows of teeth (one concave).

(*b*) Cylinder speed may be lower than for wheat.

(*c*) Adjustable sieves in chaffer, chaffer extension, and shoe should be open wider than for wheat.

(*d*) Wind adjustment must be carefully regulated to prevent oats from being blown over the rear of the machine.

Damp oat straw requires the full rated speed of the cylinder for successful threshing.

Barley.

(*a*) Four or six rows of concave teeth may be needed if the straw is tough and the beards hard to separate from the heads.

(*b*) Cylinder should be running fast—at or even a trifle above full rated speed.

(*c*) Sieve setting should be the same as for wheat, except that the rear end of shoe sieve should be set lower.

Rye.

(*a*) Two rows of teeth (one concave) are usually sufficient. Concave setting should be widened slightly if the straw is damp.

(*b*) The same sieve setting may be used as for wheat.

(*c*) More air may be used in the fanning mill than for wheat.

Flax.

(*a*) Four or six rows of teeth (two or three concaves) may be required.

(*b*) Flax must be fed in very carefully and evenly, not bunched.

(*c*) Cylinder should run at full rated speed.

(*d*) Flax should be threshed only when the straw is dry.

(*e*) Special flax sieve should be used underneath the adjustable shoe sieve. More air blast can be used with two sieves in the shoe.

(*f*) Chaffer, chaffer-extension, and adjustable shoe sieves should be closed a little more than for wheat. Chaffer-extension sieve must be open wide enough to allow the bolls to pass through to the tailings auger. The adjustable sieve should be placed as high as possible in the shoe.

There will always be more tailings in flax threshing than for other grains. Many of the seed bolls must be returned to the cylinder for rethreshing.

4. Put on the drive belt and see that it is drawn up tight enough to prevent slippage.

A good alignment of the driving pulley of the power unit and the driven pulley of the thresher cylinder is necessary to keep the belt on. This is particularly necessary in windy weather. A poor alignment may also cause the sides of the drive belts to rub on the belt guides and wear rapidly.

If possible, the machine should be set so that the wind (if any) blows from the power unit in the general direction of the thresher. This results in keeping the operators out of the dust

as much as possible. The most favorable setting is to have the wind on the quarter.

Threshers are driven from the source of power (steam, engine, farm tractor, or electric motor) by a long belt. This is called the drive belt. Drive belts are made in widths from 5 to 9 ins. and are furnished in lengths from 40 to 150 ft.

The drive belt is placed over the large pulley on the thresher cylinder. This is the main drive pulley of the thresher, and from it power is transmitted by belts to all other parts.

5. Before putting on any of the thresher belts, let the drive belt turn over the cylinder only, for a short time, to see that the teeth are properly spaced and that none strike.

6. Put on all the belts and run the machine slowly for a short time.

7. Turn down the grease cups and fill all the oil holes while the machine is running. While this is being done, any part that is not functioning properly will be noticed.

8. Run the machine at full speed for a few minutes. Check the speed of the cylinder. See that all belts are tight enough to prevent slippage. If not, some parts will not run at the proper speed.

The cylinder must revolve at the proper speed, to do good threshing. The speed of the cylinders in small threshers should be about 1075 R.P.M. The speed of the cylinders in large machines is from 750 to 800 R.P.M. The operator should know the speed at which the cylinder should run and be able to determine its exact speed. To do this, an instrument known as a speed indicator or revolution counter should be secured from the manufacturer of the thresher. It is essential that the cylinder be driven at the proper speed, because all the other parts are driven from it. If the cylinder speed slackens, the speed of the other parts decreases and clogging up may result.

9. Have the grain fed in evenly and steadily. There must be no bunching on the feeder.

10. Lubricate all parts of the machine frequently, while it is

in operation. Feel of all bearings often to locate any that are running hot.

11. Keep constant watch on the grain. Change adjustments as required to have it well cleaned.

Examine the straw to determine if any grain is going through the machine unthreshed. Change adjustments as required to get all kernels threshed out of the heads.

The adjustment of the parts mentioned in the following paragraphs should be changed, as required, to get a satisfactory job of threshing and cleaning.

(a) *Straw Grate.*—The straw grate at the rear of the cylinder is adjustable in some machines. It should be kept as high as it can be and still let the straw pass through freely. The grain is separated from the straw better with the grate high.

(b) *Beater.*—The operator should make sure that the beater is well secured to the shaft on which it is mounted. The set screws securing it to the shaft should be kept tight. Some machines provide a means by which the beater can be raised to a higher position for threshing very tough grain.

The beater should be exactly centered between the two sides of the machine.

(c) *Straw Rack.*—To do good work, the straw rack must vibrate at the proper speed. This varies on different machines, but an average rate is 200 vibrations per minute. The belt driving it must be kept tight and no slippage permitted. The bearings of the crank and pitmans must be adjusted properly or knocking and pounding will result. Both pitmans must be of the same length or the straw rack will be twisted out of shape.

(d) *Grain Pan.*—Grain is sometimes lost between the sides of the machine and the grain pan. Shields or canvas coverings are used to prevent this. They should be carefully watched to see that no leaks of grain occur.

(e) *Chaffer.*—The sieve of the chaffer should be opened wide enough to let all the good grain through to the sieves

in the fanning mill. Any grain that passes over the chaffer is either lost entirely or else drops through the sieve of the chaffer extension and returns to the cylinder through the tailings elevator.

(*f*) *Chaffer Extension.*—The openings in the chaffer extention should be made much larger than those in the chaffer.

(*g*) *Fanning Mill: Sieves.*—The position or angle of the sieves used in the cleaning shoe is adjustable, as is the size of the openings in the sieve itself. The size of the opening should be large enough to let all the grain through readily.

The sieve is usually placed in the shoe with a slight angle downward toward the fan and grain auger. Under favorable conditions the sieves can be placed nearly level.

The more nearly level the sieve is, the less readily large particles of chaff and dirt fall through the screens. For cleaning dirty grain, a heavier blast of air can be used without blowing the grain out, if the sieves are set with the front end low and the rear end high.

(*h*) *Tail Board.*—The tail board, at the end of the chaffer extension, should be raised, if necessary, to prevent the grain from being blown out into the stacker.

(*i*) *Air Blast.*—The amount of air used can be regulated by raising or lowering the doors at the side of the fan housing.

The fan must be kept tight on the fan shaft, and the fan belt must not slip. If the fan does not run fast enough, the threshed grain is often found to be dirty.

The blast of air should be strong enough to carry off all the chaff, but not so strong as to blow away the kernels of grain. It should be equally strong on all parts of the sieves. To get an even blast, the doors on each side of the fan housing must be opened equally.

(*j*) *Weed Screen.*—Screens function in a manner opposite to the sieves. The openings in the sieves are large enough to allow the good grain to pass through. The open-

ings in the weed screens are very small; they exclude the good grain but allow the small weed seeds to pass through.

Weed screens are clamped in the bottom of the shoe. They are not adjustable. Weed seeds and other foreign matter (called screenings) fall through the screen to the ground.

COMMON TROUBLES

Some of the more common threshing troubles, with their causes and remedies, are given below.

1. Cracked or Broken Kernels.

Causes.—(*a*) Uneven spacing between cylinder teeth and concave teeth.

(*b*) End play in cylinder.

(*c*) Cylinder running too fast (particularly in very dry grain).

(*d*) Uneven feeding.

(*e*) Too many rows of concave teeth.

(*f*) Concaves set too close to cylinder.

(*g*) Threshed grain returns to the cylinder and is cracked when rethreshed.

Grain that is properly threshed may return through the tailings elevator if the openings in the chaffer and chaffer extension are not large enough. (See trouble No. 3 below.)

2. Grain is not Threshed from Heads Properly.

(*a*) Cylinder speed too slow.

(*b*) Not enough rows of concave teeth.

(*c*) Concaves set too wide.

(*d*) End play in cylinder shaft.

(*e*) Worn concave teeth or worn cylinder teeth.

(*f*) Feeding too fast.

(*g*) Tough or wet straw.

The remedy for each of the above is implied in the cause of the trouble. Feeding the cylinder requires care and constant attention. The grain should be fed in with the bundles lying straight. The heads should enter the cylinder first. Too

rapid feeding or bunching the bundles on the feeder web or raddle may clog up the machine.

3. Too Much Tailings.—(Tailings elevator returns too much material to the cylinder.)

(*a*) Overloading (feeding too rapidly).

(*b*) Speed too slow.

(*c*) Too many rows of concave teeth, or concave teeth set too close. This chops up the straw, and a heavy load is thus placed on the chaffer and sieves. Much of this returns through the tailings elevator.

(*d*) Too strong an air blast. (This will cause much of the grain to be blown into the tailings auger and returned to the cylinder.)

(*e*) Openings in chaffer and shoe sieve too small. To remedy, correct whichever one of the above causes is responsible for the trouble.

4. Grain is not Well Cleaned.

(*a*) Openings in chaffer sieve or shoe sieve too large. This allows many particles of foreign matter, joints and pieces of straw, etc., to pass through the sieve openings and reach the grain auger with the grain.

(*b*) Air blast not properly adjusted—enough wind must be used to blow out the chaff. The current of air must be directed against all the under surface of the shoe sieve, not against the center portion only. An adjustable windboard is provided in some machines for this purpose.

(*c*) Agitation (shake) of the shoe not sufficient, due to a slipping belt or shoe pitmans not properly adjusted.

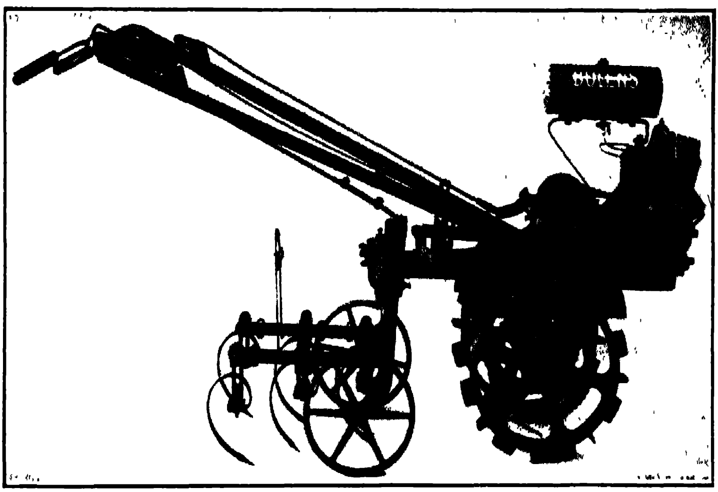
(*d*) Weed seeds in the grain. This is caused by the weed screen's not being in its proper place in the bottom of the shoe; or, as often happens, the weed screen may become plugged up.

PART II

CHAPTER XI

TRACTORS

Farm tractors were first generally used in the opening years of this century on the large grain farms of the West. The work required of them was chiefly plowing and harrowing. These first tractors were heavy and cumbersome, not suited



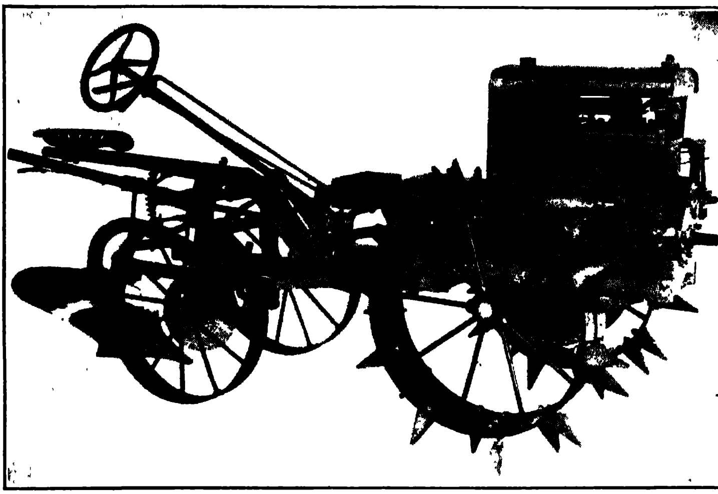
Courtesy of Gilson Manufacturing Co.

FIG. 229.—Garden cultivator.

to the small farm. The cost of such large plowing outfits was too high for the average farm owner.

Tractor manufactuers soon began producing machines of

smaller size, lighter in weight and more easily controlled. The farmer demanded a tractor adapted to his farm, one that would economically pull a two- or three-bottom plow, an 8-ft. binder or disk harrow, etc. Manufacturers continued their improvements and have now made tractor power available for many other farm operations, such as mowing, harvesting, seeding, planting, and cultivating. The problem of adapting the tractor to culti-



Courtesy of Central Tractor Co.

FIG. 230.—Small farm tractor.

vating was particularly difficult. Much definite progress has been made, and tractor cultivating has in many cases substantially cut production costs. Tractor cultivating is rapid, as two-, three-, or even four-row cultivators are used.

As a source of belt power, the tractor has been very useful. It is used for an almost endless list of farm jobs requiring belt power.

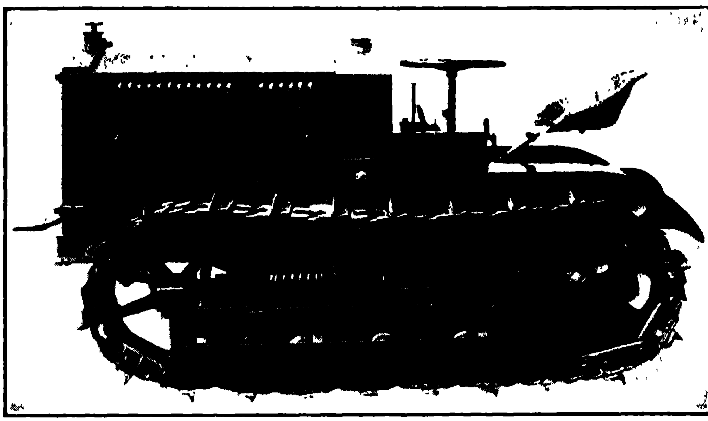
Along with the development of tractors for farming has gone the work of adapting them to industrial uses, with the

result that tractors are now widely used in industry as well as in agriculture.

The tractors used in agriculture may be divided into three classes, as follows:

1. Garden cultivators.
2. Small or auxiliary farm tractors.
3. Farm tractors.

The engine of the garden cultivator has a single cylinder. The power rating of the engines in this class is from 1 to 4 belt



Courtesy of Cleveland Tractor Co.

FIG. 231.—Track-laying type of farm tractor.

horse power. Garden cultivators are designed primarily for light cultivating and are not used for plowing. They may also be used to operate garden tools, such as seeders, weeders, hilling tools, etc., and are frequently used for lawn mowing. Figure 229 shows a standard type of garden cultivator.

Small or auxiliary farm tractors are made with single-cylinder, two-cylinder and four-cylinder engines. The power rating of machines in this class is from 5 to 10 draw-bar horse power. Such tractors are usually equipped with one 12-in. plow, and disk harrows, spike-tooth harrows, cultivators,

Courtesy of International Harvester Co.

FIG. 232.—Farm tractor with two-row cultivator.

Courtesy of Ford Motor Co.

FIG. 233.—Farm tractor filling a silo.

sprayers, etc., may be used with them. These small farm tractors are widely used on truck farms. Figure 230 shows a standard type of auxiliary farm tractor.

Farm tractors are sufficiently powerful to pull two or more 14-in. plow bottoms under average plowing conditions. Two- and four-cylinder engines are the most common. The draw-bar power of this class ranges from 10 to 30 horse power. This

Courtesy of J. I. Case Threshing Machine Co.

FIG. 234.—Farm tractor with 3-bottom plow.

class includes a greater variety of machines than either of the other two. Figure 231 shows a farm tractor of the track-laying type, particularly useful where the traction problem is difficult. Figure 232 shows a farm tractor recently developed for general farm work and well adapted to cultivating. Figure 233 shows a farm tractor being used for belt work, and Fig. 234 a tractor-plowing scene.

Certain principles of construction and engine operation are common to all tractors. Many of the repair jobs necessary on the small garden cultivators are also necessary on the large farm tractors. The following chapters treat briefly of these

basic facts. It would obviously be impossible to include in a book of this nature specific directions covering each make of tractor.

CONSTRUCTION AND PRINCIPAL PARTS OF THE TRACTOR ENGINE

1. Cylinders (Fig. 235, *C*).—The cylinders might be called the heart of the engine. The fuel, which gives the engine power, is burned within them. Tractor engines usually have more than one cylinder. The cylinders may be placed vertically (Fig. 235, *C*) or horizontally.

2. Cylinder Head (Fig. 235, *A*).—The cylinder head fits over one end of the cylinders.

3. Cylinder-head Gasket (Fig. 235, *B*).—The cylinder-head gasket is placed between the cylinder and the cylinder head, to make a tight connection between these two parts. This gasket is made of thin sheets of copper folded over a layer of asbestos.

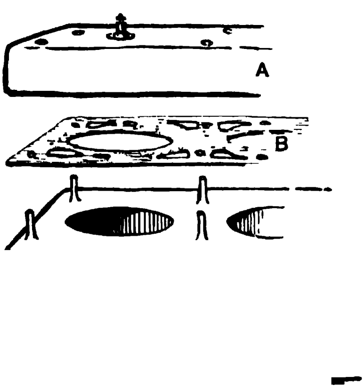


Fig. 235.—Cylinders, cylinder head gasket and cylinder-head.

4. Pistons (Figs. 236*a* and *b* and Fig. 237).—The piston is a moving part. It fits into the end of the cylinder opposite to the cylinder head. It moves up and down very rapidly when the engine is running. The piston has four distinct functions (see Fig. 237, *A*, *B*, *C*, *D*) as follows:

(*a*) It draws the fuel mixture into the cylinder (Fig. 237, *A*).

(*b*) It compresses the fuel mixture within the cylinder (Fig. 237, *B*).

(*c*) It delivers power from the burning fuel mixture to the main shaft of the engine (Fig. 237, *C*).

(*d*) It drives out the burned gases from the cylinder (Fig. 237, *D*).

These four operations are performed over and over again, always in the same order, as long as the engine is running. The four strokes of the piston are known by the following names:

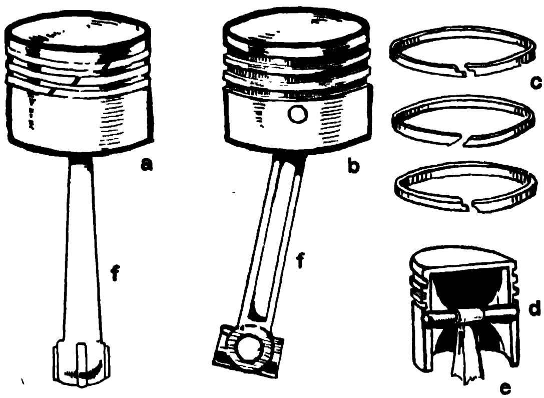


FIG. 236.—Piston, piston rings, wrist pin and connecting rod.

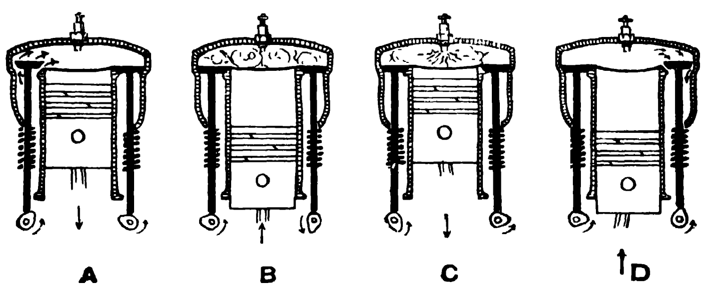


FIG. 237.—The four functions of the piston.

(*a*) Intake (Fig. 237, *A*).
(*b*) Compression (Fig. 237, *B*).
(*c*) Power (Fig. 237, *C*).
(*d*) Exhaust (Fig. 237, *D*).

Intake is a downward movement of the piston; compression

is an upward movement; power is a downward movement; and exhaust is upward.

5. Piston Rings (Fig. 236, *c*).—The piston rings make a tight connection between the piston and the wall of the cylinder. The pistons are made slightly smaller than the cylinder, so that they may be able to move up and down freely. The space between the piston and the cylinder wall is filled by the piston rings so that there will be no leaks past the piston. The piston rings are carried in grooves cut around the piston. They are made of cast iron.

6. Wrist Pin (Fig. 236, *d*).—The wrist pin fastens the piston to the connecting rod. There is a heavy pressure on the

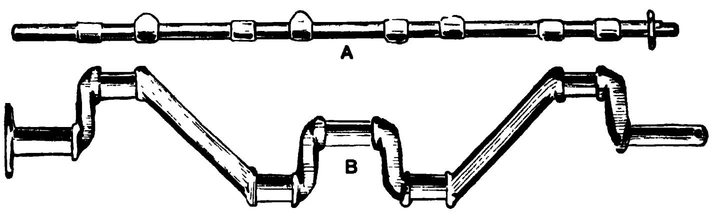


Fig. 238. —Camshaft and crankshaft.

wrist pin when the engine is running. It is made of hard steel and rests in a bronze bearing.

7. Connecting Rod (Fig. 236, *f*).—The connecting rod attaches the piston to the crankshaft. It transmits the power from the piston to the crankshaft. A bearing of babbitt metal is used at the lower end of the connecting rod. This bearing is also under great pressure and is one of the first to wear. It must be well lubricated and carefully adjusted. The adjustment of the connecting-rod bearings will be studied in Chapter XIV.

8. Crankshaft (Fig. 238, *B*).—The crankshaft is the largest shaft in the engine. It is made of steel and is supported by large babbitt bearings. These bearings must also be given very careful attention (see Chapter XIV). The crankshaft revolves and thus changes the reciprocating (up and down)

motion of the piston into a rotary (turning) motion. A rotary motion is easily transmitted by a belt or gears.

9. Flywheel.—The flywheel is carried on one end of the crankshaft. It acts as a balance and makes the engine run evenly.

10. Camshaft (Fig. 238, *A*).—The camshaft is connected by gears to the crankshaft. The revolving crankshaft causes the camshaft to revolve also. The camshaft carries on it raised pieces called cams, which open the valves, as will be explained later.

11. Valves (Fig. 239, *A* and *B*).—There are two valves in each cylinder. One of these, called the intake valve, lets fresh fuel mixture into the cylinder. The other, called the exhaust valve, lets the gases of the burned fuel mixture out of the cylinder. Both valves are closed when the piston is compressing the fuel mixture and both are closed when the piston is moving downward on its power stroke. The valves are pushed open by the action of the cams and valve tappets and are closed by strong coil springs. (Refer to Figs. 237 and 239).

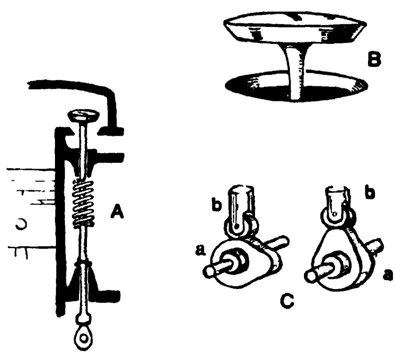


FIG. 239.—Valves, and valve action.

12. Valve Tappets (Fig. 239, *b*).—Each valve tappet is pushed up once every time the camshaft revolves. In a common type of engine, one end of the tappet rests against the cam and the other end presses against the stem of the valve. The adjustment of the valve tappets is very important and will be studied thoroughly in Chapter XIV. (Refer to Fig. 239, *A*, *B* and *C*.)

13. Timing Gears (Fig. 240).—The timing gears connect the ends of the crankshaft and the camshaft. The timing-gear attached to the crankshaft is always half the size of the gear

on the camshaft. This causes the camshaft to turn at one-half the speed of the crankshaft. When two gears are meshed together the smaller gear turns the faster. The timing gears must be meshed together at a certain point and are usually marked for this purpose. The setting of these gears determines the time in the piston stroke when the valves will open. The method of setting these gears will be studied in Laboratory Study No. 26.

14. Crankcase (Fig. 241).—The crankcase encloses the crankshaft and covers the bottom of the engine. It forms a tank or reservoir and holds the main oil supply for the engine. On four-cylinder engines the crankcase usually has four small

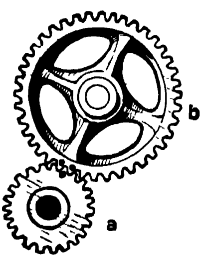


FIG. 240.—Timing gears.

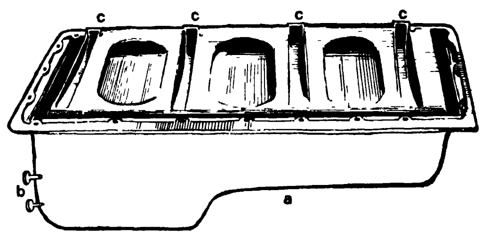


FIG. 241.—Crankcase.

troughs (Fig. 241, *c*). The connecting rods dip into these troughs and splash the oil to all parts of the engine. Usually there are petcocks or a gauge placed on the crankcase, so that it is possible to tell how much oil there is inside of it (Fig. 241, *b*).

15. Governor.—The governor regulates the speed of the engine and prevents it from running too fast. It is driven by the motor and regulates the engine speed by increasing or decreasing the amount of fuel mixture entering the cylinders.

16. Water Jacket.—The water jacket is the space between the cylinder and the outer wall of the engine. This space must be kept full of water. When the engine is running the water circulates through this space, thus keeping the engine cool.

LABORATORY STUDY NO. 23

To remove the crankcase and locate and examine the parts of the engine.

Equipment Necessary.—Any complete tractor engine. The engine need not be in running condition, but all the parts should be in their proper positions.

Procedure.

1. Drain the oil from the crankcase.
2. Remove the crankcase from the engine.
3. Examine the crankshaft and answer the following questions.
   (*a*) How many crankshaft bearings do you see?
   (*b*) How is the flywheel fastened to the crankshaft?
   (*c*) How does the oil get into the crankshaft bearings?

4. Examine the crankcase and answer the following questions:
   (*a*) What kind of an oil-level gauge is used?
   (*b*) How high should the oil level be on the inside of the crankcase?
   (*c*) Do you find an oil strainer in this crankcase?

5. Find the oil pump and answer the following questions:
   Note.—Some tractors do not have an oil pump.

   (*a*) What drives the oil pump?
   (*b*) Is it a plunger type or gear type of pump?
   (*c*) Does the pump force the oil to the troughs in the crankcase?
   (*d*) Locate all the oil pipes and tell what parts of the engine they lead to?

6. Examine the camshaft and answer the following questions:

(*a*) How many cams do you see?
(*b*) Crank the engine and see how many times you have to turn the crankshaft to make the camshaft turn around once.
(*c*) How many bearings does the camshaft have?
(*d*) What parts do the cams move?

7. Examine the connecting rods and answer the following questions:

(*a*) How are the connecting rods attached to the crankshaft?
(*b*) What would happen if a connecting rod should come loose when the engine was running?
(*c*) What is the purpose of the small dipper or scoop on the end of each connecting rod?

Note.—In tractors where oil is forced to all parts, this scoop is not used.

8. Make sure that all the connecting-rod bolts are tight and secured with a cotter pin.

9. Examine the crankcase gasket. If it has been broken or torn, a new one should be used. If a new one is not at hand, cut one out of a sheet of heavy paper. Rub both sides of the gasket well with oil or grease.

10. Replace the crankcase and tighten all the bolts.

LABORATORY STUDY NO. 24

To remove the cylinder head and locate and examine parts of the engine.

Equipment Necessary.—Same as for Laboratory Study No. 23.

Procedure.

1. Drain the water from the radiator.
2. Loosen all connections between the cylinder head and the radiator.
3. Take out all cylinder bolts and remove the cylinder head. Be careful not to break or tear the cylinder-head gasket
4. Locate the valves and answer the following questions:

   (*a*) Are the valves in the cylinder head or are they in the same casting with the cylinders?
   (*b*) Which are the intake valves and which are the exhaust valves?
   (*c*) What closes the valves?
   (*d*) Name all the parts that act to open the valves.
   (*e*) How would dirty valves affect the running of the engine?

5. Locate the water-jacket space around the cylinders.

   (*a*) How does the water pass from the water jacket into the cylinder head?
   (*b*) Does this water pass through the cylinder-head gasket?

6. Crank the engine until No. 1 piston (the one nearest the crank) is at the top end of the cylinder. This point is called "top center." Now crank the engine until No. 1 piston is at the bottom end of the cylinder. This point is called bottom center.

(*a*) How far does the piston travel in moving from " top center " to " bottom center "? This distance is called the " stroke " of the piston.

7. Examine the cylinder-head gasket carefully. Clean it off well with sandpaper. If it is broken, dented, or burned, it must be replaced with a new one. Grease both sides of this gasket well and put it in place on the cylinders. Shellac may be used on the cylinder-head gasket instead of grease.

8. Replace the cylinder head. Tighten down all the cylinder-head nuts evenly. Draw down each nut a little at a time until all are tight. Do not draw one nut completely tight and then go to the next one.

9. Make all connections tight between the cylinder head and the radiator.

10. Refill the radiator. Watch for water leaks. Tighten the connections where any leaks are noticed. A slight water leak will gradually " take up " and stop leaking.

Note.—Sometimes, in order to get the cylinder head tight, it is necessary to run the engine and get it warm. Then the cylinder-head nuts can be given a final tightening while the engine is warm.

LABORATORY STUDY NO. 25

To determine: 1. How the fuel mixture is drawn into the cylinder.
2. How the fuel mixture is compressed.
3. How the burning fuel mixture forces the piston down on its power stroke.
4. How the burned gases of the fuel mixture are driven out of the cylinder.

Equipment Necessary.—Any tractor engine that is in running condition. An engine with the spark plug directly over the piston is desirable. With such a motor it is easy to find the position of the piston by putting a measuring rod down through the spark-plug hole. For this problem, only one cylinder should be studied.

Procedure.

1. Crank the engine until the exhaust valve in No. 1 cylinder just closes. This places No. 1 piston on or very near "top center."

2. Hold your hand over the air intake of the carburetor (Fig. 242, *C*). It may be necessary to disconnect the air pipe from the carburetor. Have some one crank the motor quickly for just one half turn. During this half turn you will see the intake valve open and feel the suction of the piston on your hand. This stroke of the piston draws the fuel and air past the open intake valve into the cylinder. The piston moves away from the cylinder head on this stroke (Fig. 237, *A*).

3. Give the crank another half turn. It cranks harder during this half turn. Both valves are closed. This stroke of the piston compresses the fuel mixture and is called the "compression" stroke. The piston moves toward the cylinder head on the compression stroke (Fig. 237, *B*).

4. Give the crank another half turn. Watch the valves. Does either valve open? The piston moves away from the

(*c*) Why are both valves closed on the compression stroke of the piston?

(*d*) Why are both valves closed on the power stroke of the piston?

9. Remove the case that covers the timing gears.

10. Pull the camshaft (large timing gear) forward just so far that it is out of mesh with the crankshaft gear (small timing gear).

11. Turn the crankshaft until the piston in No. 1 cylinder (nearest the crank) is in the same position as it was when the exhaust valve closed in Step No. 7 in this problem. (This will be on or very near top center.)

12. Turn the camshaft in the proper direction (opposite direction to that of crankshaft) until the exhaust valve just closes.

13. Mesh the two gears together, being careful not to let either one turn out of position.

14. Now crank the engine until the timing marks on the gears come together (Fig. 240). If these marks line up properly, your work is correct. If they do not, repeat the work again.

Note.—The student should practice this timing exercise until he can mesh the gears correctly without depending on the marked teeth.

LABORATORY STUDY NO. 27

To determine the causes of poor compression.

Equipment Necessary.—The following parts of any tractor engine.

1. Cylinder.
2. Cylinder head.
3. Cylinder-head gasket.
4. Piston.
5. Piston rings.
6. Exhaust valve.
7. Intake valve.
8. Valve springs and retainers.

Only one cylinder need be studied in this problem.

Procedure.

1. Put the cylinder head and cylinder-head gasket in place on the cylinder. Draw it up tight.
2. Put the piston rings on the piston.
3. Rub the piston, piston rings, and cylinder wall with oil.
4. Put the valves in their proper places and have them both closed tightly.
5. Push the piston into the cylinder and notice how strong the compression feels. Try this several times, then pull the piston out of the cylinder.
6. Hold the intake valve slightly open and push the piston into the cylinder again. Is there good, strong compression now? Pull the piston out again.
7. Hold the exhaust valve slightly open. Push the piston into the cylinder. How is the compression? Pull the piston out.
8. Loosen the nuts that hold the cylinder head until the cylinder head and gasket are not tight against the cylinder. Push the piston into the cylinder and test the compression. Pull the piston out and tighten the cylinder head down again.
9. Wipe piston, piston rings, and cylinder thoroughly dry of

oil. Push the piston into the cylinder and test the compression again. Pull the piston out.

10. Remove the piston rings. Push the piston into the cylinder and test the compression.

Questions:

(*a*) Name five troubles that cause leaks of compression.
(*b*) Why does weak compression make the engine run badly?
(*c*) What compresses the gas in the cylinder?
(*d*) Do the piston rings ever wear out?
(*e*) Why must the piston be well oiled?
(*f*) How does an open valve affect the compression?

FUEL AND CARBURETION SYSTEM

The fuel burned in tractor engines is usually gasoline or kerosene. Enough for several hours' work must be carried on the tractor. It must be kept very clean and be carefully strained before it enters the engine. Before the fuel can be burned in the cylinder, it must be changed from liquid to vapor. The fuel vapor must then be mixed with a certain amount of air. Tests show that the right proportions for this mixture are about 15 parts of air to 1 of gasoline. If this proportion is changed very much, the fuel mixture will not burn readily and the engine will lose power.

Tractors work in the dusty fields. If dusty air were drawn directly into the cylinders, the engine would soon be worn out. The air to be mixed with the fuel vapor must first be washed or strained.

The parts of the fuel and carburetion system that accomplish these things are described in the paragraphs that follow. Carburetors will be carefully studied in Chapter XII also.

1. Fuel Tanks (Figs. 242, *k* and *l*).—The fuel tanks are usually made of galvanized iron. There are two tanks, or two compartments in one tank, the smaller one for gasoline and the

larger for kerosene. Gasoline is used to start the engine. When the engine has been warmed up, kerosene can be used. The engine cannot be started on kerosene.

2. Fuel-tank Valves (Fig. 242, *j*).—The fuel-tank valves are directly below the tanks. They may be closed to shut off the flow of fuel from the tanks to the carburetor. Most tractors have two of these shut-off valves, one under the gasoline tank or compartment, and one under the kerosene.

3. Fuel Pipes (Fig. 242, *h*).—The fuel pipes are small copper

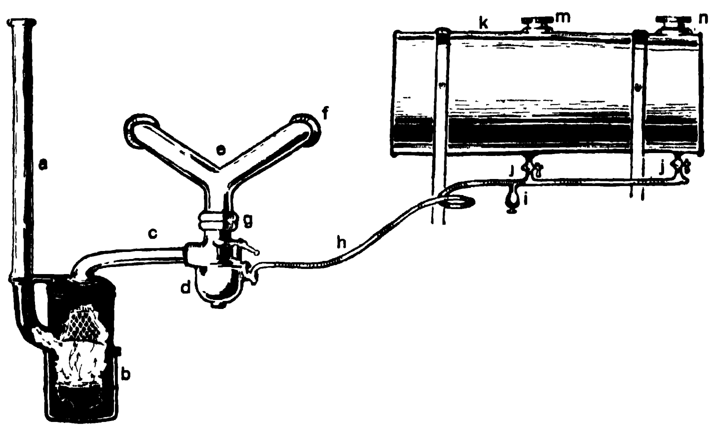


Fig. 212.—Fuel and carburetion system.

tubes. They allow the fuel to flow from either tank to the carburetor.

4. Sediment Bulb (Fig. 242, *i*).—The sediment bulb is a small bowl containing a fine wire strainer. All the fuel must pass through this strainer, which removes all dirt and sediment. The sediment bulb is constructed so that any water that may be in the fuel will gather in the bottom of the bulb and may be drawn off by the drain cock.

5. Filler Caps (242, *m* and *n*).—The filler caps screw into the top of each tank. The fuel is poured in through them. Each filler cap has in it a small air hole, which must be kept open.

If the air holes become closed the fuel will not flow down to the carburetor.

6. Carburetor (Fig. 242, *d*).—The carburetor has three distinct functions:

(*a*). To change the liquid fuel to vapor.

(*b*) To mix the fuel vapor with air.

(*c*). To keep the fuel vapor and air in the right proportion.

Liquid fuel and air enter the carburetor; a mixture of fuel vapor and air leaves it. The carburetor and its various parts and adjustments will be studied in Chapter XII.

7. Throttle (Fig. 249, *c*′).—The throttle is a small disk in the carburetor, where the carburetor is attached to the intake pipe. This may be closed or opened to regulate the amount of fuel mixture entering the cylinders. In this way, the setting of the throttle controls the speed of the engine. The throttle is operated by the driver of the tractor, by means of a small lever placed near his seat.

8. Governor.—The governor is made up of two small weights, which spread apart as the motor speed increases. The spreading apart of these governor weights is adjusted by springs. The weights are connected by a small rod to the throttle in the carburetor. The action of the governor weights automatically regulates the throttle and causes the engine to maintain a uniform speed.

9. Air Cleaner (Fig. 242, *b*).—The air cleaner removes dust from the air entering the carburetor. There are many different kinds of air strainers. In some the air is passed through or over water; in others it is filtered through oil or drawn through a very fine screen.

10. Intake Pipe (Fig. 242, *e*).—The intake pipe carries the fuel mixture from the carburetor to the cylinder.

LABORATORY STUDY NO. 28

To locate and examine the various parts of the fuel and carburetion system.

Equipment Necessary.—Any tractor engine in which all parts of the fuel and carburetion system are in place.

Procedure.

1. Examine the fuel tanks and answer the following questions:

   (*a*) How many tanks are used?
   (*b*) Is there an air-vent hole in the filler cap?
   (*c*) Is there a shut-off valve under each tank?
   (*d*) Why are the fuel tanks higher than the carburetor?

2. Locate the sediment bulb and open the drain cock at the bottom of it.

   (*a*) Is there a strainer or screen in this sediment bulb?

3. Take off the fuel pipes between the tanks and the carburetor.

4. Clean these pipes carefully and replace them. Be sure that all nuts on the fuel pipes are tight, so that the fuel will not leak out. It is a good plan to cover the threads on the joints in the fuel pipes with soap. This will make a good tight connection.

5. Trace the path of the air from the point where it enters the air strainer, to the carburetor.

6. Disconnect the carburetor from the intake pipe, and answer the following questions:

   (*a*) Why is a gasket used at this connection?
   (*b*) What would be the result of a loose connection at this point?

7. Connect the carburetor carefully to the intake pipe. Use a new gasket if the old one is not in perfect condition. Oil or shellac this gasket.

8. Locate the drain cock at the bottom of the carburetor. Why is this at the lowest point in the carburetor?

IGNITION SYSTEM

The word ignition is derived from the Latin word *ignis*, which means fire. The ignition system provides a means of setting fire to the fuel mixture inside of the cylinder. Electricity is used for this purpose in tractors, because it is very dependable and can be accurately controlled.

The electricity for ignition may be generated in two ways, by a battery or by a magneto.

1. Batteries.—A battery is a group of cells. One cell is shown in Fig. 251, *a*. Such cells generate electricity by the chemical action of certain elements within them. There are two kinds of battery cells in general use.

(*a*) *Dry-cell Batteries.*—Such batteries are called "dry" because the cells contain no liquid. They do not last long and must be thrown away when they are used up, but they are the cheapest in first cost.

(*b*) *Storage Batteries.*—A battery of this type is quite large and heavy. It is made of two kinds of lead plates and is filled with dilute sulphuric acid. When a storage battery has run down it may be renewed. To do this it is necessary to pass a current of electricity through the battery for several hours. This process is called "charging the battery." Storage batteries are much more expensive than dry-cell batteries in first cost, but they last much longer.

Batteries are not often used on tractor engines. Storage batteries are commonly used in automobiles because they will furnish light for night driving, power for cranking the engine by means of the self starter, and current for sounding the horn, as well as electricity for ignition.

2. Magneto.—The magneto is a small, compact machine, driven by the engine (Fig. 256). It generates electricity whenever the engine is running. It is very dependable, and if

given good care will last as long as the engine to which it is attached. The magneto is a very important part of the tractor. If it ever fails, the engine will stop at once. Every student who wishes to become a good tractor operator must study the magneto thoroughly. All of Chapter XIII will be given to the magneto and the ignition system.

3. Ignition Wires.—Copper wires carry the electricity from the magneto or battery to the cylinders of the engine. Copper is used because electricity flows through it very easily. These copper wires are wrapped with a covering of cotton, silk, or rubber. Such materials are called "Insulators" or "Insulation." They prevent the electricity from leaking out of the wire into any metal that the wire might touch. The wires that carry the current to the cylinders are heavily insulated, as this current is under a very high electrical pressure and would easily break through a thin insulation.

4. Induction Coils.—In some engines there is a device called an "induction coil" between the magneto or battery and the cylinder. The induction coil transforms the current coming from the magneto or battery into a current of much higher electrical voltage (pressure) before it goes to the cylinder. Induction coils will be explained further in Chapter XIII.

Ignition systems that do not use induction coils transform the electricity into a current of high voltage within the magneto itself. Magnetos of this type are known as "high-tension magnetos."

5. Spark Plugs.—The spark plug causes the electric current from the magneto or battery to make a spark. It is this spark that lights the fuel mixture. Each cylinder has one spark plug. The bottom part of the spark plug has two small wires, called "electrodes." Between these electrodes there is a small air space or gap. The electric current, because it is under high voltage (pressure), jumps across this gap, thus making a spark. Figure 257 shows a cross section of a spark plug.

LABORATORY STUDY NO. 29

To see and test the spark.

Equipment Necessary.—Any tractor engine with a high-tension magneto, complete with wires and spark plugs. (Drain the fuel out of the carburetor to be sure the engine will not start, and remove all but one spark plug so that the engine will crank easily.)

Procedure.

1. Disconnect the wire from the one spark plug left in the cylinder. Hold the end of the wire $\frac{1}{4}$ in. away from the metal of the engine. (Do not let the hand touch a part of the wire that is not insulated.) Crank the engine rapidly and watch the spark jump across this $\frac{1}{4}$-in. air space. Hold the wire $\frac{1}{2}$ in. away and try it again. Does the spark jump $\frac{1}{2}$ in.? The spark should be strong enough to jump $\frac{3}{8}$ in.

2. Take out the spark plug and lay it down on top of the engine. Be sure that the bottom (not the top) of the plug touches a metal part of the engine. Connect the spark-plug wire to its proper place at the top of the plug.

3. Crank the engine and watch the spark jump between the electrodes of the plug.

4. Determine, as nearly as possible, what position the piston is in when the spark occurs. Is it near top center or bottom center?

5. Replace the spark-plug wire with an old wire from which a strip of the insulation has been removed. Let the bare part of this wire rest against a metal part of the engine.

6. Crank the engine again and see if there is a spark between the electrodes of the plug. A condition like this is called a "short circuit."

7. Replace the spark plugs in the cylinders and attach the wires in their original position.

LUBRICATION SYSTEM

Wherever two moving parts of a machine rub together, wearing or friction occurs. Friction causes a loss or waste of useful power. Friction cannot be eliminated entirely but it must be reduced as much as possible. Lubrication or oiling is the best method of reducing friction.

All the moving parts of a tractor must be carefully lubricated, with just the right kind of oil or grease. The kind of lubricant to use depends upon the following factors:

1. How fast the parts move.
2. How closely the parts are fitted.
3. How much strain or pressure the parts are subject to.
4. How much heat the parts are subject to.

The engine parts are very closely fitted. They move fast, are under heavy strain, and get very hot. Consequently, they must be lubricated with a high-grade, light oil, refined especially for this purpose. The gears and shafts in the transmission and differential are lubricated with a heavy oil or semi-fluid grease. These parts move more slowly and do not get as hot as the engine parts. The tractor wheels are lubricated with a heavy grease. These parts move slowly and will not get hot if given plenty of grease.

1. Lubrication of Engine Parts.—The oil for the pistons, cylinders, bearings of the connecting rods, crankshaft and camshaft, valve tappets, and all internal parts of the engine is carried in the reservoir at the bottom of the crankcase (Fig. 241).

There are two commonly used methods of distributing the oil from this reservoir to the engine parts. Most farm tractors have a pump which pumps the oil from the bottom of the crankcase to the troughs shown in Fig. 241 *c*. The connecting rods dip into these troughs and splash the oil to all parts. This is known as the "circulating-splash system." In other engines, the oil pump forces the oil directly to all parts. This is called the "force-feed" system.

It is necessary to have just the right amount of oil in the

crankcase. Too much oil will cause the engine to give off white smoke at the exhaust. The inside of the cylinders, the valves, and the spark plugs will become covered with carbon very quickly if there is too much oil.

Too little oil will cause the motor to overheat, lose power, and wear rapidly. Because it is so important to have just the right amount of oil in the engine, oil gauges are provided on most engines. These gauges show the level of the oil in the crankcase. The level of the oil should always be tested before starting an engine. This test cannot be made accurately when the motor is running (see oil petcocks on the crankcase, Fig. 241, *b*).

2. Lubrication of Transmission.—The transmission must also be kept supplied with just the right amount of lubricant. If too much is used, some of it usually leaks out and is wasted. In some tractors this oil may leak on to parts that should *not* be lubricated and cause trouble. An insufficient amount of transmission oil will cause rapid wear and heating of the transmission shafts, gears, and bearings. In order that the proper amount of transmission oil may be kept in the tractor, a removable plug is usually screwed into the transmission case, and the oil level should be kept up to this plug (Fig. 245, *i*).

3. Lubrication of Differential.—The amount of oil in the differential casing must also be just right. Too much will mean a waste of oil and may bring more serious trouble. Too little will cause overheating and rapid wear.

An oil-level plug is also provided in the differential so that just the proper amount of oil may always be put in (Fig. 245, *g*).

In some tractors the transmission and differential are contained in the same housing and are lubricated from the same oil supply. In this case, one oil-level plug only is needed.

4. Lubrication of Wheels and Axles.—The wheels and axles are usually provided with screw-cap grease cups. These caps are filled with grease and screwed down. This forces the grease into the bearing. Such grease caps should be screwed down one

or two turns every few hours while the machine is in operation.[1]

The hub caps of the front wheels on most tractors are made to serve as a grease cup. They must be kept well filled with grease, not only because this makes the wheels turn easily, but also because it prevents dust and grit from getting in and wearing out the wheel bearings (Fig. 265).

5. Lubrication of Steering Arms and Joints.—The steering arms or joints and all other external parts that move or pivot should be oiled frequently. A hand oil-can may be used for this purpose. The same oil that is used for the crankcase of the engine is the most convenient for the purpose. A cheaper oil will be satisfactory if it is available. (See Fig. 264.)

6. Lubrication of Clutch-shifting Yoke.—The clutch-shifting yoke (Fig. 214, *b*) attaches the clutch-shifting pedal to the clutch. This must be well lubricated, as there is apt to be much wear at this point. In some tractors this yoke is lubricated with grease, and in others it runs in oil. If grease cups are used to lubricate the clutch yoke, they should be turned down every few hours while the tractor is running.

When gasoline is used for fuel, all the oil in the crankcase of the engine should be drained out, and fresh oil put in, once every sixty hours of operation. If kerosene is used, the oil should be changed every forty hours. The oil in the transmission and differential need not be changed so often. Changing this once every thirty days should be sufficient. In some tractors, however, this oil will last much longer. It is well to test the oil frequently to see if it still retains its lubricating quality. If it is soft and "buttery" it is still good. If it is light and feels like kerosene it should be changed immediately.

[1] Many tractor manufacturers have now adopted the high pressure lubrication system, described in Chapter II, or some similar system.

LABORATORY STUDY No. 30

To lubricate all parts of the tractor.

Equipment Necessary.—Any tractor that is in running condition. All the oil should be drained out of the engine crankcase, differential case, and transmission case. All grease cups should be emptied and cleaned. The purpose of this problem is to give the student an opportunity to go through every step in lubricating the entire tractor.

Procedure.

1. Find the oil-level indicator on the crankcase of the engine. Pour in motor oil through the oil-filler pipe until the oil-level gauge on the crankcase shows the proper level.

(*a*) How much oil does this require?

2. Find the oil-level plug on the transmission. Pour in transmission oil until it runs out of this plug.

(*a*) How much transmission oil is required?

3. Find the level plug on the differential. Pour in oil through the filler plug until it runs out of this plug. How much is required?

Note.—In some tractors the transmission and differential receive the oil from the same supply. In this case only one level plug and one filler plug is provided for both.

4. Find all the grease cups on the tractor and fill the grease-cup caps with grease. Put them on and give each one several turns.

Make a list of all the places that grease cups lubricate.

5. Find all the places that should be lubricated with a hand oil-can, and oil them.

Make a list of all places where a hand oil-can should be used.

6. Tell how the valve stems are lubricated.

7. Answer the following questions:

(*a*) How often should the engine crankcase be drained of oil and refilled with fresh oil?
(*b*) How often should the oil in the transmission be changed?
(*c*) How often should the oil in the differential be changed?
(*d*) What will be the result of having too much oil in the engine crankcase?
(*e*) What will be the result of having too little oil in the engine crankcase?
(*f*) What will be the result of having too much oil in the transmission or differential?
(*g*) What will be the result of having too little oil in the transmission or differential?
(*h*) How is clutch-shifting yoke lubricated?

COOLING SYSTEM

When the fuel mixture is compressed and burned within the cylinders, an intense heat is set up. Just after the spark occurs and the fuel mixture catches fire, a temperature of 3000° F. or more is reached. If this heat were not quickly conducted away, the oil on the pistons and cylinders would burn up, the pistons would stick, and the engine would stop.

Water is used in most engines to carry away this heat. The water must circulate and be kept cool or it would soon boil away.

The parts of the system that keep the water cool and cause it to circulate around the cylinders are given below.

These parts are all shown in Fig. 243, and the course of the circulating water is indicated by the arrows.

1. Water Jacket.—The water jacket is the space surrounding each cylinder. This space is kept full of water. The heat on the inside of the cylinder passes through the walls of the cylinder to the water in the jacket.

2. Radiator Intake Pipe (Fig. 243, *E*).—The radiator intake pipe connects the water jackets of all the cylinders to the top

of the radiator. In some engines this radiator inlet is a metal pipe, and in others it is a rubber hose.

3. Radiator (Fig. 243, *A*).—The radiator carries off, or "radiates," the heat from the cooling water. It must keep the water from boiling. The top of the radiator is in the form of a tank or reservoir (*B*). There is also another tank at the bottom of the radiator (*C*). These two tanks are connected by a very

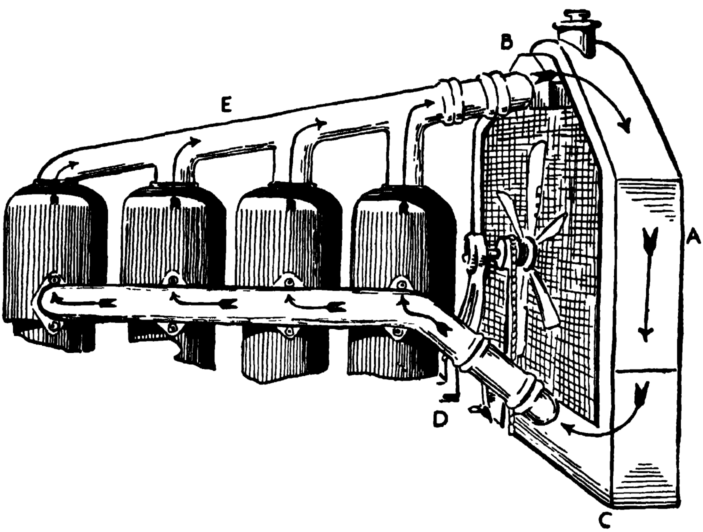


Fig. 243.—Cooling system (Thermo-syphon).

large number of metal tubes or cells. This peculiar construction causes the water to touch a large amount of metal, which absorbs the heat from the water.

4. Radiator Outlet Pipe (Fig. 243, *D*).—The radiator outlet pipe connects the bottom tank of the radiator to the bottom of the water jacket.

5. Fan (Fig. 243).—The fan is used in connection with the radiator to keep the water cool. It is driven by the engine and revolves very rapidly, drawing a current of air through the radi-

ator. This current of air carries the heat away from the metal tubes or cells of the radiator, thus helping to keep the water cool.

Figure 243 shows how the water circulates through the cooling system. As soon as the engine is started, the water in the water jackets becomes heated. Water, when heated, rises. The water in the jackets rises, therefore, and flows up through the radiator inlet pipe to the top part of the radiator. This hot water is replaced by cool water, which flows from the bottom of the radiator through the radiator outlet pipe or hose to the bottom of the jacket.

The circulation of the water, then, is as follows: up from the water jacket, through the radiator inlet pipe to the top of the radiator; down through the radiator, where it is cooled, to the bottom of the radiator; back through the radiator outlet pipe to the bottom of the water jacket.

The radiator must be kept full whenever the engine is running, or the water will not circulate. Whenever there is danger of freezing, all the water should be drained out of the cooling system when the tractor is not in use. If the water should freeze in the engine it would crack the water jackets or cylinders.

The cooling system described above is a simple one. It is known as the " thermo-syphon " system. Many tractors have a water pump as a part of the cooling system. The water pump forces the water to circulate and gives a surer circulation than the " thermo-syphon " system, which depends on heat alone.

CLUTCH

The clutch is a device used on tractors to connect and disconnect the engine and the transmission. When the clutch is thrown out (disengaged) the engine is free to run without turning the shafts in the transmission. When the clutch is in (engaged) the engine is directly connected to the transmission.

A simple type of clutch is shown in Fig. 244, *A* and *B*. It is made up of the parts described in the paragraphs that follow.

1. Clutch Plates (Fig. 244, *e* and *d*).—This clutch has two plates. One of the plates is connected to the flywheel of the engine, and the other to the transmission shaft. This second plate is keyed on to the transmission shaft so that it can slide back and forth through a short distance. Both of these plates are faced with fiber linings.

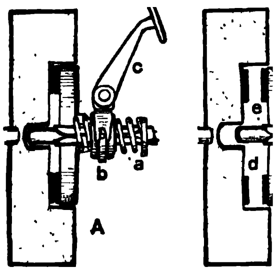


FIG. 244.—A simple type of clutch. *A*, clutch engaged. *B*, clutch disengaged.

2. Clutch Spring (Fig. 244, *a*).—The clutch spring is usually a heavy coil spring that presses the two plates of the clutch tightly together when the clutch is engaged.

3. Clutch Yoke (Fig. 244, *b*).—The clutch yoke fits into a groove cut around the rear clutch plate. The clutch yoke connects the rear plate of the clutch to the clutch lever or pedal.

4. Clutch Lever or Pedal (Fig. 244).—The clutch lever may be either a foot pedal or a hand lever. It is used by the operator to engage or disengage the clutch. The clutch lever is always connected to the clutch-shifting yoke.

There are many different kinds of clutches. Proper care of the clutch and caution in operating it are very important.

The clutch should be disengaged only while the gears are being shifted in the transmission. If it is kept disengaged long, when the engine is running, the linings on the clutch plates and the clutch-shifting yoke will wear out quickly.

TRANSMISSION

Tractors are used for many different kinds of work. It may be necessary to use a tractor to pull a very heavy load up a steep hill. In this case the engine must run fast and the rear wheels must turn slowly. Or it may be necessary to pull a light load along a good level road by means of a tractor. In this case

it would be desirable to have the motor run more slowly and the wheels of the tractor go faster than in the previous case.

This relation of the engine speed to the speed of the drive wheels is controlled largely by the gears in the transmission.

Most tractors have three different speeds, or " gear changes " (sets of gears), in the transmission for moving the tractor forward, and one set of gears for moving it backward.

Figure 245, *h*, will serve to illustrate the action and location of the transmission. It is not, however, an exact reproduction of any particular transmission. The lower shaft shown in the

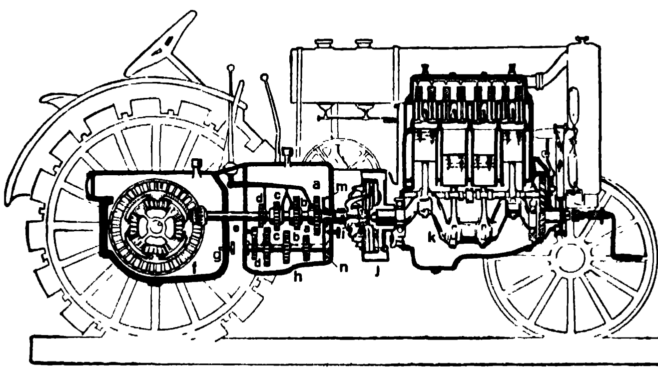


FIG. 245.—Cross section of tractor.

transmission in Fig. 245, *h* carries four gears. These gears are keyed fast to the shaft. The lower shaft itself is connected by gears (*m* and *n*) through the clutch to the engine. The two gears (*m* and *n*) shown in solid black are always in mesh. Neither of them is a sliding gear. The upper shaft also has four gears. These gears are keyed to the shaft so that they may slide a short distance in either direction. The upper shaft is directly connected to the differential, but has no direct connection with the clutch.

1. Low Speed.—On the upper shaft, gear *a* is the largest, gear *b* is of medium size, and gear *c* is smaller than *b*. On the

lower shaft, gear *a* is the smallest, gear *b* is of medium size, and gear *c* the largest.

When two gears are meshed together, the smaller one always revolves the faster. Therefore, if, in the transmission shown in Fig. 245, gear *a* on the upper shaft were moved backward until it meshed with "*a*" on the lower shaft, the upper shaft would be turning slowly. As this upper shaft is connected to the rear drive wheels, they would also be turning slowly. This set of gears would be used for pulling heavy loads.

This combination of the transmission gears is called "low speed."

2. Intermediate Speed.—If the set of gears lettered *b* in Fig. 245 were meshed together, the upper shaft would not turn as slowly as when the gears lettered *a* were together. This combination gives "intermediate speed."

3. High Speed.—When the gears lettered *c* are meshed together the upper shaft turns rapidly because gear *c* on the upper is small compared with "*c*" on the lower shaft. This causes the rear wheels of the tractor to revolve fast, and this combination of gears gives "high speed."

4. Reverse.—Between gear *d* on the lower shaft and gear *d* on the top shaft, there is a small gear, *e*, which is called an idle gear. This gear is carried on a short stub shaft. If gear *d* on the upper shaft is moved backward until it meshes with gear *e*, the upper shaft will be turned in the opposite direction. This causes the tractor to back up, hence this combination is called "reverse."

5. Gear-shifting Lever.—The gears on the upper shaft are shifted by the operator with the gear-shifting lever. Whenever a gear is shifted the clutch must be thrown out so that the gears on the bottom shaft stop revolving. If this is not done the gears will grind together and be broken.

When the gears are set so that none are in mesh between the bottom and top shafts, they are said to be in "neutral." They should always be placed in "neutral" before starting the engine.

DIFFERENTIAL, REAR AXLES, DRIVE WHEELS

Most tractors are driven by the two rear wheels. The power given the piston by the burning fuel mixture is carried back through all the parts that have been described, until it finally reaches the rear wheels. These drive the tractor forward or backward at the will of the operator.

In some tractors the power is finally delivered to the rear wheels by means of chains, but usually the rear axles serve as drive shafts, by means of which the power is transmitted to the rear wheels (see Fig. 246, *B*).

Figure 245 shows the parts through which the power passes,

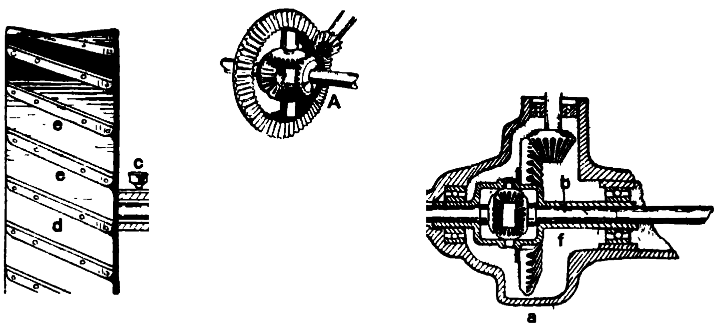


FIG. 246.—Differential, rear axles and drive wheel.

from the piston, through all the tractor parts, to the drive wheels.

1. Differential (Fig. 246, *A* and *B*).—As both rear wheels are drive wheels, it is sometimes necessary that one of them turn faster than the other. This is the case when turning a corner. The outside wheel must then travel faster than the inside wheel as it has farther to go. Yet both wheels are always being driven by the engine whenever the tractor is moving. The differential gears work automatically and are not controlled by the operator (see Fig. 246, *A*). Whichever wheel meets the greater resistance from the ground will begin to

slow up. When turning a corner, the wheel on the inside of the turn meets more resistance. It therefore turns more slowly than the wheel on the outside of the turn.

The differential is usually placed midway between the two drive wheels (Fig. 246, *f*). It is enclosed in an oil-tight case (Fig. 246, *a*) and must be well lubricated, as explained.

2. Rear Axles (Fig. 246, *b*).—The rear axle is usually made in two parts or halves. They connect from each side of the differential to the rear wheels, and carry the power from the differential to the drive wheels. These axles are supported by bearings, and a grease cup is provided for lubricating them (Fig. 246, *c*).

3. Rear Wheels (Fig. 246, *d*).—The rear wheels are rigidly attached to the rear axles. Tractor wheels are always equipped with cleats or lugs (*e*) so that they will have a firm grip on the ground. There are many kinds of tractor-wheel lugs. It is necessary to have the proper type for the kind of soil on which the tractor is working. If the drive wheels slip and do not get a firm grip, it is impossible to do good work.

The lugs must be kept tight. If they come loose when the drive wheels revolve, they may catch in other parts of the tractor and cause serious damage.

Extension rims should be used on the drive wheels for very soft or loose soil. These give the tractor a better hold on the ground and keep the wheels from slipping.

LABORATORY STUDY NO. 31

To study the action of clutch, transmission and differential.

Equipment Necessary.—Any tractor in running condition.

Precaution.—For this exercise the spark plugs should be taken out so that the engine will not start, but will crank easily. Before disconnecting the spark-plug wires, mark them so that they may be put back in the proper order.

Procedure.

1. Jack up the rear end of the tractor so that the drive wheels are off the floor.
2. Put the gear-shifting lever in neutral. Engage the clutch and crank over the motor. Do the rear wheels turn?
3. Put the gear-shifting lever in low speed. Engage the clutch and crank over the motor. Do the rear wheels turn? Count the number of times it is necessary to turn the crank around to make the rear wheels turn around once.
4. Put the gear-shifting lever in high speed. Engage the clutch. Count how many times it is necessary to turn the crank to make the rear wheels turn once.
5. Put the gear-shifting lever in reverse. Engage the clutch and crank the engine. Notice the direction in which the rear wheels move.
6. Put the gear-shifting lever in low speed. This time do not engage the clutch. Hold it out. Crank the engine. Do the rear wheels turn?
7. Put the gear-shifting lever in high speed. Hold the clutch out. Crank the engine. Do the rear wheels turn?
8. Put the gear-shifting lever in reverse. Hold the clutch out. Crank the engine. Do the rear wheels turn?
9. Put the gear-shifting lever in low speed. Engage the clutch. Have some one hold the left rear wheel. Crank the engine. Does the right rear wheel turn?
10. With the gear-shifting lever in low speed and the clutch

engaged, have some one hold the right rear wheel. Crank the engine. Does the left rear wheel turn?

11. With the gear-shifting lever in low speed and the clutch engaged, have two students hold both rear wheels. Crank the engine. What happens?

12. Try holding first one and then the other rear wheel when cranking the engine with the gear-shifting lever in reverse and the clutch engaged. What happens?

13. Explain fully the purpose of the clutch.

14. Explain fully the purpose of the differential.

LABORATORY STUDY NO. 32

To trace the path of the power from the piston through all parts to the drive wheels.

Equipment Necessary.—Any complete tractor. Refer to Fig. 245.

Procedure.

1. Locate the pistons of the engine.

   (*a*) What shaft carries the power from the pistons to the flywheel?

2. Locate the clutch.

   (*a*) Is the clutch operated by a hand lever or a foot pedal?
   (*b*) What parts of the tractor are connected by the clutch?

3. Locate the transmission.

   (*a*) Between what two parts of the tractor is the transmission located?
   (*b*) Why are several sets of gears or speed changes necessary in the transmission?

4. Locate the differential.

   (*a*) Why is a differential necessary?
   (*b*) How is the differential connected to the drive wheels.

5. List in order the parts through which the power is carried.

6. Examine the drive wheels and answer the following questions:

   (*a*) How are the lugs fastened?
   (*b*) Is there any device to prevent the lugs from coming loose?
   (*c*) Is it possible to attach extension rims to these drive wheels?

CHAPTER XII

TRACTOR CARBURETORS

The carburetor has three distinct functions, as follows:

1. To vaporize the liquid fuel.
2. To mix this fuel vapor with air.
3. To measure out the proper amounts of fuel and air to be mixed together.

Figure 247 illustrates the parts and the action of a simple carburetor. The gasoline flows down into the carburetor from the tank through the gasoline pipe, past the needle valve (*a*) and up into the spray nozzle (*c*).

The upper end of the large pipe (*d*) is connected to the cylinders. Air enters this pipe at the lower end. The air is drawn through the pipe by the suction of the pistons in the engine.

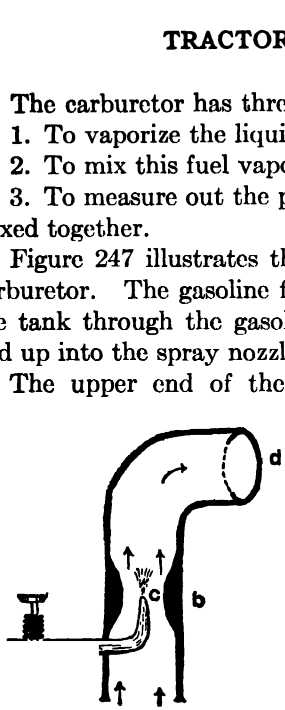


FIG. 247.—Simple Carburetor.

As the air rushes by the spray nozzle (*c*) it draws the fuel out. The tip of the spray nozzle has one or more small holes. When the liquid fuel is drawn through these holes it breaks up into a fine spray or vapor. This vapor mixes with the air and is carried into the cylinder. The spray nozzle, then, accomplishes the first of the three things listed above.

The air passage is made narrow at the point where the spray nozzle is located. This construction is called the "venturi tube." The purpose of the venturi tube (Fig. 247, *b*) is to

make the air move faster at the point where it meets the fuel vapor. This causes a more thorough mixing of the air and fuel vapor. The venturi tube accomplishes the second of the three functions of the carburetor.

The needle valve (Fig. 247, *a*) measures the amount of liquid fuel that comes out of the end of the spray nozzle. Closing the needle valve lessens the amount of liquid fuel to be mixed with the air. Opening the needle valve increases the amount. The needle valve accomplishes the third function of the carburetor.

Tractor carburetors must have a supply of liquid fuel very near the spray nozzle. The level of the fuel must be kept just below the tip of the nozzle. To accomplish this, the device shown in Fig. 248, *a*, is used. This is called a float. The supply of fuel for the spray nozzle is carried in the float chamber. The float is made of cork or light, hollow metal, such as brass.

When fuel is poured into the tank and the shut-off valve below the tank is opened, the fuel flows down into the float chamber, causing the float to rise. The float carries a little valve on top of it, called the float valve. The float rises until it causes the float valve to seat into the fuel pipe above it. This prevents any more fuel from entering the float chamber.

The float and float valve are so made that the level of fuel in the float chamber and spray nozzle will be just the same. This level should be just below the tip of the spray nozzle.

The float is automatic in action. The float chamber is filled to the proper level when the engine is started. As the engine runs, fuel is used out of the spray nozzle. Fuel from the float chamber runs into the spray nozzle to replace what is used. When fuel flows out of the float chamber the float is lowered. This opens the float valve and allows more fuel to enter the float chamber from the tank.

FLOAT TROUBLES

The float and float valve are simple in construction. If properly cared for, they give little trouble. Occasionally the following troubles may be encountered.

1. Dirt on Float-valve Seat.—This will keep the float from closing completely and will cause the fuel to overflow and leak from the carburetor.

2. Float Valve Worn.—It is possible for the float valve to become worn in such a way that it will not shut off completely.

3. Float Level too High.—In some carburetors the connection between the float and the float valve is adjustable. In this case it should be set so that the level of the fuel is held just below the tip of the spray nozzle. If the level is too high, fuel will leak from the carburetor, through the tip of the spray nozzle. If the level is too low, the fuel will not be drawn out of the spray nozzle in sufficient quantity to give the proper mixture to the cylinders.

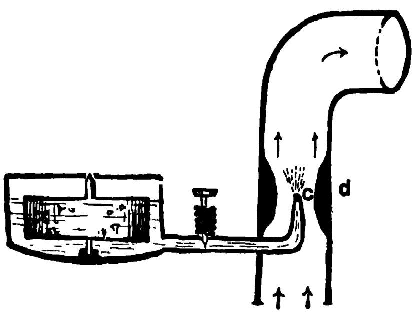


Fig. 248.—Simple carburetor with float.

4. Float too Heavy.—Cork floats may lose their buoyancy and become heavy. Metal floats may be punctured or become porous. This will allow liquid fuel to get inside and make the float heavy. Cork floats should occasionally be taken out, allowed to dry thoroughly, and then covered with a coating of shellac or varnish. Metal floats should be taken out and tested to see if they contain any liquid. If so, this may be evaporated by heating, and the holes soldered. Sometimes these holes are so very small that it is very difficult to find them. Therefore, if a metal float gives trouble it is usually best to replace it.

TRACTOR CARBURETORS

The simple carburetors in Figs. 247 and 248 are shown to explain how the three chief functions of the carburetor are accomplished. Tractor carburetors are somewhat more complex than these simple ones. Tractor engines do not run at one speed only. They must be flexible, must idle down to a few hundred R.P.M. (revolutions per minute), or must turn up to 1000 R.P.M. or more.

The carburetor must furnish just the right amount of air and fuel at all times, no matter how fast or how slow the engine is running. To do this, a more complete carburetor is required than the simple forms shown.

A cross-section view of a complete carburetor is shown also in Fig. 249. This carburetor is used on many tractor engines.

Fuel enters the carburetor from the fuel tank through the float valve (*i*) and passes into the float chamber (*j*). This causes the cork float (*k*) to rise, and the float valve closes. The level of the fuel is kept just below the spray nozzle (*l*). The needle valve (*b*) screws down into a small hole in the top of the float chamber. This is called the needle-valve seat. When the needle valve is closed no liquid fuel can be drawn from the float chamber past the needle-valve seat.

The air enters the carburetor at the air intake (*g*). The air passage is narrowed down at the venturi (*m*). It is here that the air meets the fuel, which is drawn past the needle-valve seat and out of the spray nozzle (*l*). If the engine is running slowly the air and fuel vapor pass up through the low-speed tube (*h*) past the throttle (*c*) and on into the cylinder.

Secondary Air Valve (*a*).—As the engine speed increases more fuel is drawn into the mixture than is required. The mixture would be too rich in fuel unless some means were provided to overcome this difficulty. There are two possible ways of doing this. One is to lessen the amount of fuel coming from the spray nozzle at high engine speed; the other is to increase the amount of air available at high engine speed.

This carburetor uses a very simple device to add extra air to the mixture when the engine runs fast. This is a lead weight hinged to one side of the air passage (*a*). It is called a secondary or auxiliary air valve. When the engine is running

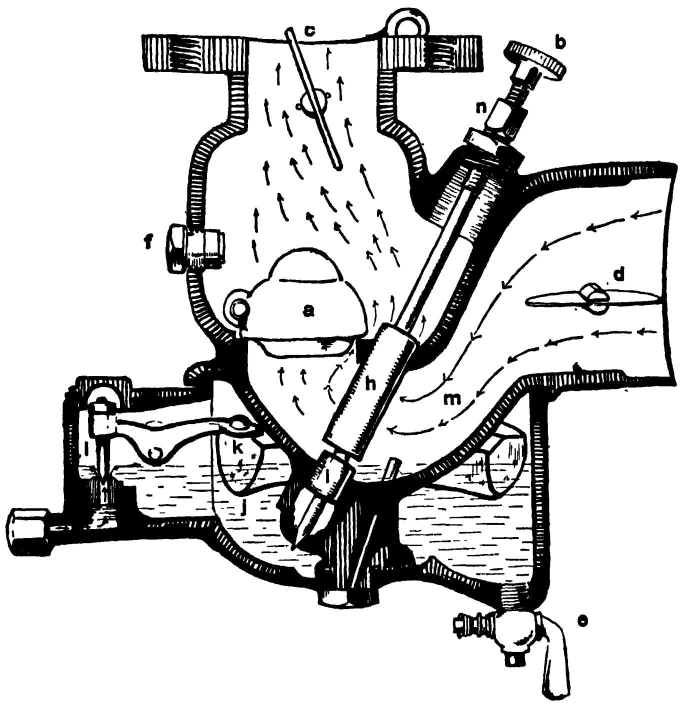


FIG. 249.—Cross section of tractor carburetor.

slowly this weight rests on its seat, thus closing off the main air passage. The mixture then travels up the low-speed tube (*h*) on its way to the cylinders.

As the engine speed increases, the suction of the pistons increases also. The suction becomes strong enough to raise the secondary air valve off its seat. This increases the size of the

air passage, thus adding more air or weakening the mixture at high speeds. The action of the secondary air valve is entirely automatic. It gives the right amount of air at all times.

Back of the secondary air valve is a stop or plug (*f*) to prevent the secondary air valve from tipping back too far or becoming stuck in the open position.

This air valve gives very little trouble, but it might possibly become stuck on the shaft. If so it would not move easily and would not give a proper mixture at all speeds.

Choke Valve (*d*).—At the point where the air enters the carburetor, a choke valve is placed. This is in the form of a small disk. It is used to close the air passage when starting the engine. The choke valve is operated by the tractor driver. If it is held closed while the engine is being cranked, a mixture very rich in fuel vapor will be drawn into the cylinder.

The choke valve is usually operated by a wire which is attached to it. With this wire the operator may hold the valve closed with one hand while he cranks the engine with the other. When the operator releases the wire the choke valve automatically springs open.

The choke valve should be used only when starting the engine and then it should be used as little as possible. If it is used too much, the mixture drawn into the cylinders may be so rich in fuel vapor that it will not burn. The use of the choke valve is necessary when starting the engine in cold weather.

Needle Valve (*b*).—The needle valve regulates the amount of fuel to be mixed with air. This adjustment should be accurately set after the engine has warmed up. Turning the needle valve to the right, or clockwise, lessens the amount of fuel or makes the mixture "lean." Turning it to the left, or anti-clockwise, increases the amount of fuel or makes the mixture rich.

The engine will not run perfectly if the mixture is too "rich" or too "lean." If it is too rich the engine will give off black smoke and soon begin to misfire. If it is too lean the engine will "back-fire" through the carburetor and lose power.

Throttle (*c*).—The throttle controls the amount of mixture to be admitted to the cylinders. In this way it controls the speed of the engine. It looks very much like the choke valve. The throttle is controlled by the operator by means of a small lever, which is usually attached to the steering wheel.

The throttle may also be operated automatically by the governor of the engine.

Drain Cock (*e*).—The drain cock placed in bottom of the float chamber has a very important function. Liquid fuel usually has some water or dirt in it, no matter how carefully it has been handled. When such matter enters the carburetor it sinks to the lowest part of the float chamber, which is directly above the drain cock. This drain cock should be opened frequently to drain off water and sediment.

Carburetor Trouble.—Carburetor trouble is caused by anything that changes the proportion of air and fuel vapor going to the cylinders. If these proportions are changed even slightly, the engine will immediately begin to slow up and lose power. Any one of the troubles listed below may occur when the engine is running.

The following conditions may cause the mixture to become too lean.

1. Fuel tank empty.
2. Needle valve closed too far.
3. Dirt or sediment in fuel tanks, fuel pipes, or carburetor.
4. Float valve out of adjustment so that it closes too quickly.
5. Air leaks between carburetor and cylinders.
6. Water in fuel.
7. Air vent in fuel tank closed.
8. Secondary air valve stuck open.

Whenever the mixture becomes too "lean," some of the indications listed below may be noticed.

1. Engine back-fires, or pops back through the carburetor.
2. Light-yellow flame may be seen in the cylinder if the operator opens the cylinder relief cock.

3. Engine misfires and runs unevenly.

4. Engine speed increases if the operator opens needle valve slightly.

The following list contains the usual causes of the mixture becoming too rich.

1. Needle valve open too far.
2. Float too heavy or punctured, letting too much fuel into the float chamber.
3. Float valve dirty or worn, and therefore not closing properly. This lets too much fuel into the float chamber.
4. Air passage closed or obstructed.
5. Choke-valve spring broken.
6. Secondary air valve stuck in closed position.

Whenever the mixture becomes too rich, some of the following indications may be noticed.

1. Black smoke from exhaust pipe.
2. Dark-red flame seen in cylinder if the cylinder petcock is opened.
3. Smell of raw fuel at exhaust pipe.
4. Engine misfires and runs unevenly.
5. Spark-plug electrodes foul quickly.
6. Engine speed increases if the operator closes the needle valve slightly.

CARE OF FUEL AND CARBURETION SYSTEM

The instructions given below should be followed carefully. It is necessary to take good care of the fuel and carburetion system.

1. Keep all gaskets between the carburetor and cylinders tightly fitted.
2. Keep fuel-pipe connections tight. Soap used on the threads of these connections will help to prevent leaks.
3. Strain all the fuel carefully when it is put into the fuel tanks.

4. Drain the sediment bulb and float chamber of the carburetor often, to remove any water that has collected.

5. Be sure that the needle-valve adjustment is secured by the binding nut (Fig. 249, *n*). The vibration of the engine will cause the needle valve to work loose unless this binding nut is kept fairly tight.

6. Keep the air-vent holes in the fuel tanks open.

7. Clean the air strainer often. Keep it filled to proper level (if liquid is used).

8. Store the tractor in a closed shed when it is not in use. This is necessary in the general care of the tractor but particularly important in order that the fuel and carburetion system may be kept clean.

LABORATORY STUDY NO. 33

To adjust the carburetor.

Equipment Necessary.—Any tractor engine in running condition.

Procedure.

1. Open the valve under the gasoline tank and let the carburetor fill up with gasoline.
2. Open the needle valve about $1\frac{1}{2}$ turns. Have the instructor help you start the engine and let it run a few minutes to warm up.
3. Open the needle valve (anti-clockwise) gradually, until black smoke is seen at the exhaust pipe and the engine begins to slow up. The mixture is now too " rich."
4. Close the needle valve gradually until the black smoke disappears and the engine begins to speed up again. Now the mixture is nearly right.
5. Continue to close the needle valve gradually until the engine begins to slow up again. Listen carefully and you will hear a popping noise in the carburetor; the engine is backfiring through the carburetor because the mixture is too " lean."
6. Open the needle valve again, gradually, until you find the place where the engine runs the best.
7. Tighten the needle-valve binding nut until the needle valve can just be turned with the fingers (Fig. 249, *n*).

Note.—The directions given above apply to the type of carburetor illustrated in Fig. 249. The adjustment of other types may be slightly different. The object of the study, however, may be easily accomplished with any tractor carburetor. The mixture should first be made too rich, then too lean, and finally properly adjusted.

METHODS OF HEATING THE FUEL MIXTURE

In most tractors some means is provided in the carburetion system for keeping the fuel mixture hot. Heat causes the fuel to vaporize more easily and the fuel mixture to burn more readily. When kerosene is used as fuel, heat is essential. Kerosene will not vaporize readily until it is heated.

The source of this heat is usually the exhaust gases. When these gases are driven out of the cylinder by the exhaust stroke of the piston they retain much heat. Three methods of applying this heat to the fuel mixture are in common use:

1. The exhaust manifold is placed so as to surround the intake manifold. The hot exhaust gas in this case passes over the outer surface of the intake manifold, and heats the fuel mixture.

2. The air entering the carburetor is drawn from near the hot exhaust pipe, which causes heated air to mix with the fuel vapor within the carburetor.

3. The hot exhaust gas is directed through a jacket surrounding the float chamber of the carburetor. This method heats the liquid fuel.

CHAPTER XIII

MAGNETOS AND IGNITION

The magneto generates the electricity for lighting the fuel. Magnetos are used on nearly all tractors. Very few tractors use batteries.

A successful tractor operator must understand the magneto and the other parts of the ignition system thoroughly. It is estimated that three-fourths of all engine troubles occur in the ignition system.

The " magneto " is so named because one of its chief parts is a large magnet. This magnet is made of hard steel and retains its magnetism permanently. The magnet is often made in several sections (Fig. 252, *A*). There is a peculiar relation between magnets or magnetism and electricity; either can easily be made to produce the other. If magnetism is available, it can be made to produce electricity; or, if electricity is available, it can be made to produce magnetism.

If we have a horseshoe magnet such as is shown in Fig. 250, *a*, and a coil of wire wrapped on a soft-iron core, we can generate electricity. When the iron core with the coil is moved up or down as shown by the arrow, a current of electricity will be generated. This will be a very feeble current, but a delicate electrical measuring instrument (*G*), connected between the ends of the coil of wire, will indicate its passage.

The strength of the current in this simple magneto depends upon three things.

1. Strength of the magnet.
2. Speed with which the core is moved.
3. Amount of wire in the coil.

If we have electricity available it is easy to produce magnetism. Figure 251, *a*, shows a small dry-battery cell. If several turns of wire are wrapped around a soft-iron rod (*c*) and the two ends of the wire connected to the battery as shown, the iron rod will be a magnet just as long as the switch (*b*) is closed. The bar will then attract the nail (*d*) to it. As soon as this

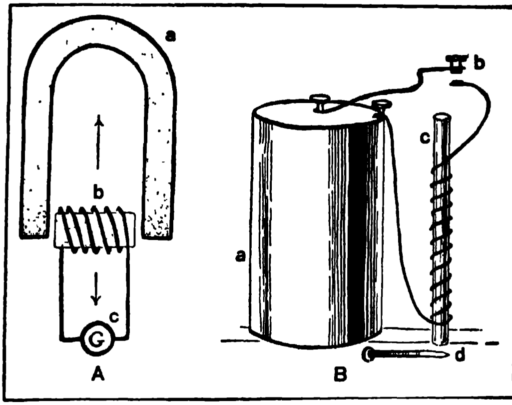


FIG. 250.—Generation of electricity from magnetism.

FIG. 251.—Production of magnetism from electricity.

switch is opened, the iron bar will lose its magnetism and the nail will drop.

The strength of the magnetism in the bar depends upon the following factors:

1. Strength of the electric current flowing around it.
2. Number of turns of wire wrapped around it.
3. Material in the bar itself. (Soft iron may be magnetized quickly and demagnetized quickly; hard steel will become magnetized slowly and lose magnetism slowly.)

Both of the principles described above are made use of in the construction of magnetos. The magnetism of the large permanent magnets on the outside of the magneto (Fig. 252, *a*)

is used to generate a low-pressure current of electricity. This is called the primary current. This primary current flows through a coarse wire wrapped around a soft-iron core (Fig. 254, *b*). Whenever the primary current flows, the core is magnetized. Over the wire through which the primary current flows there is another winding consisting of many thousands of turns of very fine wire (hair size). In some magnetos there is as much as two miles of this fine wire. This is called the secondary winding.

As long as the current flows steadily through the primary

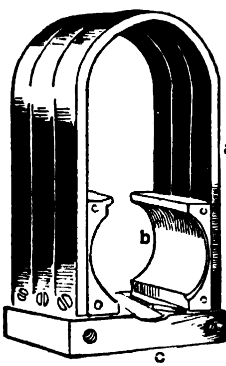


Fig. 252.—Magnets, pole shoes and base of a high-tension magneto.

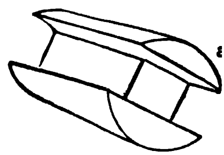


Fig. 253.—Armature core.

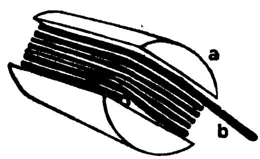


Fig. 254.—Armature core with primary winding.

circuit there is no current in the fine wire of the secondary winding. When the primary current is suddenly stopped by opening its circuit (just as the flow of current was stopped by opening the switch shown in Fig. 251, *b*), the core upon which both windings are wrapped loses its magnetism, and a very high-pressure current is induced in the secondary circuit.

The strength of current in the secondary circuit depends upon the following factors:

1. Number of turns of wire in the secondary winding.
2. Strength of magnetization in the core (Fig. 253, *a*).

3. Quickness with which the core is demagnetized.

Note.—The magnetism is withdrawn from the core immediately when the primary current stops flowing, just as it was in Fig. 251, *b*, when the switch was opened.

The secondary current in the magneto is very strong because magnetos are built to take advantage of all three of the above points.

1. There is a very great amount of wire in the secondary winding.

2. The core is very strongly magnetized when the primary current is flowing.

3. This magnetism is instantly broken down when the primary circuit is opened.

In all magnetos there is a circuit-breaker in the primary circuit. This corresponds to the switch in Fig. 251, *b*. The circuit-breaker stops the flow of the primary current by the opening of two platinum points called " breaker points " (Fig. 255, *c*). Whenever these points open, the primary current stops flowing, the core loses its magnetism, and a very high-pressure current springs up in the secondary winding.

One end of the secondary winding leads to the spark plug (Fig. 255, *h*, *k*, *i* to *j*). It is this high-pressure current that jumps across the electrodes of the plug and sets fire to the fuel mixture in the cylinder.

The illustrations in Figs. 252 and 251 show in a simple way the peculiar relation between magnetism and electricity. The magneto makes use of this relation, but differs from these simple forms in actual construction.

The principal parts of a standard type of magneto are described in the paragraphs that follow:

1. Magnets and Magneto Base (Fig. 252, *a* and *c*).—Magnetos may be made with a single magnet, or two or more magnets may be used. They are placed as shown in Fig. 252, *a*, with like poles on the same side of the magneto. When like poles are placed together, the magnets will *not* attract but will repel each other. If the magnets should be put on the mag-

neto so that the ends attracted each other, there would be no current generated.

The magneto base (*c*) is made of brass or other non-magnetic material. This causes all of the magnetism to act through the core, which revolves between the magnets. Magnetism cannot pass through the base.

2. Pole Shoes (Fig. 252, *b*).—The pole shoes concentrate the magnetism at the ends of the magnets. They are shaped to conform to the shape of the core which revolves between them (Fig. 253, *a*).

3. Core.—Figure 253, *a*, shows the soft-iron core on which the two windings are wrapped. This core revolves inside of the pole shoes shown in Fig. 252, *b*. It takes the place of the core shown in the simple magneto, Fig. 250, *b*. This core revolves between the poles instead of being moved back and forth as was the one in the simple magneto (Fig. 250).

4. Primary Winding.—The primary winding is first wound on the core as shown in Fig. 254. It consists of fairly coarse, insulated copper wire. One end of this wire is bared and grounded to the metal core. The other end is connected to the breaker points as shown in Fig. 255, *c*.

5. Secondary Winding (see diagram Fig. 255, *h*).—The secondary winding is wrapped over the primary. It consists of very fine, insulated copper wire. The insulation is scraped off one end, and the bare wire is grounded to the metal core, usually at the same point at which the primary winding is grounded. The secondary winding is wrapped around the core, over the primary wire. Many thousand turns of secondary wire are wrapped on, and finally one end is brought out as shown in Fig. 255, and is connected to a brass ring called the collector ring (Fig. 255, *k*).

6. Collector Brush (Fig. 255, *i*).—This is a small, stationary carbon brush that is pressed down against the collector ring. It picks up the electric current that comes out of the secondary winding.

7. Distributor Arm (Fig. 255, *b*).—The collector brush carries the current to the distributor arm. This is a revolving arm,

driven by the upper shaft in the magneto. As the distributor arm revolves it comes into contact with the four segments (*a*) to which the spark-plug wires are attached. Thus it distributes the high-tension current to the different cylinders in proper order.

8. Breaker Points (Fig. 255, *c*).—Electricity is generated in the primary winding whenever the magneto begins to turn. This current flows from the winding out to the breaker points, as shown in the illustration. When these points are together, the current can flow across the points and back through the metal of the magneto to the point where the primary winding is grounded.

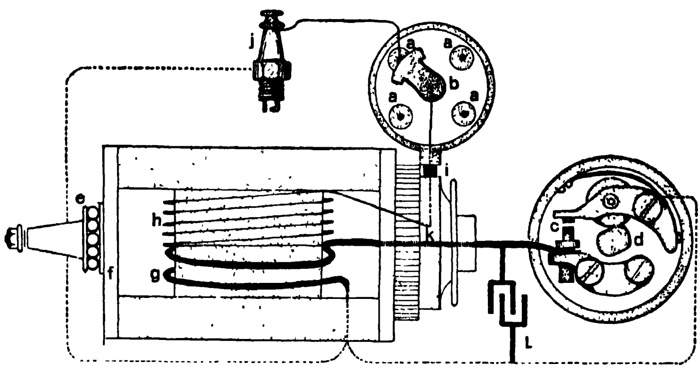


FIG. 255.—Cross section diagram of high-tension magneto.

Whenever the current is flowing, it strongly magnetizes the core on which it is wound. At the instant the breaker points open, this current stops flowing, and the core loses its magnetism. This quick change in the magnetic strength of the core generates or induces the current in the secondary winding.

Electric and magnetic action takes place so quickly that we may say that all the following events occur at the same instant:

1. Breaker points open.
2. Current stops flowing in primary circuit.
3. Current springs up in secondary circuit.
4. Spark jumps between electrodes of the spark plug.

9. Complete Armature (Fig. 255).—Non-magnetic disks are placed across the ends of the core. The core, with the windings and collector ring, is mounted on a steel shaft, which is supported by ball bearings at both ends (Fig. 255, *e*). This assembly of parts is called the armature.

10. Condenser (Fig. 255, *L*).—The condenser might be called an electric sponge. It is made up of alternate sheets of tin foil and mica. It has the capacity to store up electricity for a short time. One side of the condenser is connected to the primary wire leading to the breaker points, and the other side is grounded as shown in Fig. 255, *L*. The condenser prevents the breaker points from burning out and also makes possible a quicker and more complete stoppage of the primary current.

11. Breaker-point Cam.—One end of the armature shaft carries a cam, such as that shown in Figs. 255, *d*, and 256, *d*.

As the armature shaft revolves, the high point of the cam strikes the movable breaker point and forces the points apart.

There are two high points on the cam, as shown; therefore, the points will be opened twice for each revolution of the armature.

12. Advance and Retard of Spark (Fig. 256).—The housing, or shell, that covers the breaker points (256, *e*) can be shifted a short distance. This movable housing is connected by rods to a small lever on the steering wheel. By means of this small lever, the operator may shift the breaker-box housing as necessary. Shifting this housing causes the spark to occur in the cylinder earlier or later with regard to the position of the piston.

If the spark occurs when the piston is starting down on its power stroke, as in Fig. 237, *c*, it is said to be late or retarded.

If the spark occurs before the piston reaches top center on the compression stroke, it is said to be early or advanced.

Both of these positions of the spark are necessary. The spark must be retarded when the engine is cranked, and it should be advanced as soon as the engine starts. When the engine is being cranked, the piston moves very slowly. If the

spark should occur too early, the piston would not have reached top center by the time the fuel had fully caught fire. The burning fuel would "kick" the piston back, and the motor would try to run backwards. When the engine is running, the piston is moving fast and the spark should occur a little before top center so that the piston will reach top center when the fuel has fully caught fire. Then the full force of the burning fuel will push it downward on the power stroke.

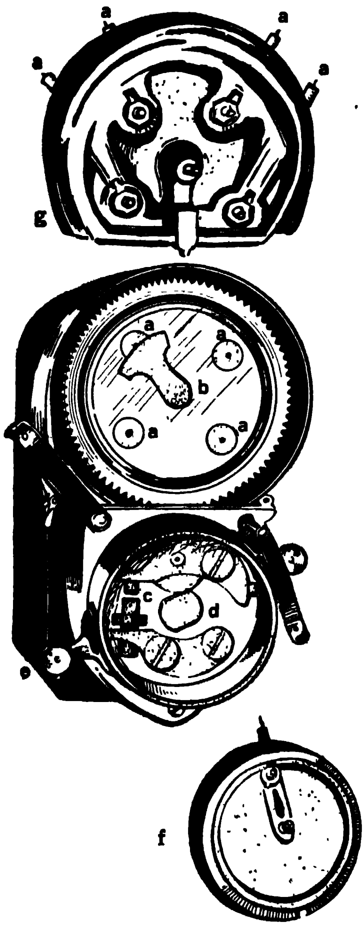


FIG. 256.—Front view of magneto (distributor head and breaker-box cover removed).

13. Breaker-box Cover and Shorting Switch (Fig. 256, *f*).—The breaker points are enclosed by an insulated cover, which keeps them clean and dry. A flat metal spring is attached to the breaker-box cover (Fig. 256, *f*). The inner end of this spring is connected to the primary circuit of the magneto. The outer end of the metal spring is connected to a wire which leads to a grounded switch near the steering wheel. Closing the switch diverts the current from the breaker points and grounds it. With the switch closed, therefore, there is no

interruption of the flow of current in the primary circuit, and accordingly no current is induced in the secondary circuit and no sparks occur in the spark plugs. This switch is called a shorting switch and affords a convenient method of stopping the engine.

Some magnetos are designed so that the shorting switch is closed by means of the movable breaker-box housing, shown in Fig. 256, *e*. Moving this housing to the full retard position closes the switch and grounds the primary current.

14. Impulse Starter.—The strength of the spark delivered from a magneto increases as the speed of the armature increases. Therefore, it is likely to give a weak spark when the engine is being cranked, as the magneto is then turning very slowly. To overcome this, a device called the impulse starter is placed on many magnetos. With this device, when the engine is cranked, a spring connected to the magneto armature is compressed and automatically released just as the piston is in the position to receive the spark. The action of this spring throws the magneto armature forward rapidly, and a strong spark is produced.

LABORATORY STUDY NO. 34

To find the firing order of a four-cylinder engine. (The firing order is the order in which the power strokes occur.)

Two cylinders never fire at the same time if the engine is running properly; they always fire one after the other in the regular order. When the last one has fired, the first one is just ready to fire again. This gives an even steam of power.

Equipment Necessary.—Any four-cylinder engine with all valves and pistons properly assembled.

Procedure.

1. Remove the case or plate which covers the valve stems and valve springs. In some tractors this case is on top of the cylinder head, and in others it is on one side of the engine.

2. Locate all the intake valves, and mark them with chalk or pencil. The intake valve in any one cylinder opens immediately after the exhaust valve in the same cylinder has closed. No. 1 cylinder is the nearest to the crank, or it may be said to be the farthest from the flywheel. Starting from No. 1, the cylinders are numbered in direct order back to the flywheel, 1–2–3–4. No. 4 cylinder is nearest the flywheel.

3. Hold your fingers on the four intake valves. Have some one crank the motor over very slowly. After No. 1 intake valve has opened, see which opens next. Then find which is next and which is last. The order in which the intake valves open is the same as that in which the cylinders fire.

In four-cylinder engines, where the cylinders are vertical, there are only two firing orders possible. The order must be either 1–2–4–3 or 1–3–4–2

Job No. 36

TO TIME THE MAGNETO TO THE ENGINE

Equipment Necessary.—Any complete tractor engine with magneto and spark-plug wires removed.

Note.—Timing the magneto consists in connecting it to the engine so that as each piston reaches top center after completing compression, the magneto will be ready to deliver the spark to it. In brief, this process consists of two simple steps: first, to have No. 1 piston in the proper position to receive the spark; and second, to have the magneto just ready to deliver the spark to No. 1 spark plug.

Operations Necessary to Perform the Job.

1. Find firing order of engine.
2. Place No. 1 piston on top center at end of compression stroke.
3. Retard spark.
4. Revolve magneto armature in proper direction until breaker points begin to open.
5. Connect magneto to engine.
6. Remove distributor cover and see which segment distributor brush is touching.
7. Connect a wire from this segment to No. 1 spark plug.
8. Connect wires to the other spark plugs, according to the firing order.

Description of Operations.

1. Find the firing order of the engine (see Laboratory Study No. 34).

2. Crank the engine until piston No. 1 just reaches top center. This position may be found by inserting a rod or wire through the spark-plug hole. Another method is to crank the engine until the exhaust valve in No. 4 cylinder just closes. This will leave No. 1 piston on or very near top center. The latter method can be used only on four-cylinder engines.

3. Place the breaker-box arm (Fig. 256, *e*) in the full retard position. This is done by moving the arm as far as possible in the direction in which the armature shaft revolves when it is driven by the engine.

4. Turn the armature shaft until the breaker points just begin to open. It will be necessary to remove the breaker-box cover (Fig. 256, *f*) to see this.

5. Connect the magneto to the motor with the coupling provided. In making this connection, do not change the position of the piston or the armature shaft any more than necessary to make the connection.

6. Remove the distributor cover (Fig. 256, *g*) and see which of the four segments the distributor arm points to.

7. Connect a wire from this segment to No. 1 spark plug.

8. Connect wires from the other segments to the spark plugs, according to the firing order of the engine. Keep in mind the fact that the distributor arm turns in the opposite direction from the armature shaft.

Job No. 37

TO LUBRICATE, CLEAN, AND ADJUST A HIGH-TENSION MAGNETO

Note.—A magneto that does not use separate induction coils between the magneto and the spark plugs is called a high-tension magneto. This type is used on most tractor engines. The magneto used in the Fordson tractor, as described on page 413, is a low tension magneto. Induction coils are placed between the magneto and spark plugs.

Equipment Necessary.—High-tension magneto.

Operations Necessary to Perform the Job.

1. Remove distributor cover.
2. Clean revolving arm or brush of distributor.
3. Clean stationary segments or brushes of distributor.
4. File breaker points.
5. Adjust breaker points.
6. Clean and lubricate bearings.

Note.—The magneto need not be removed from the engine for this job.

Description of Operations.

1. Remove the distributor cover from the magneto (Fig. 256, *g*).

2. Wipe off the distributor arm (Fig. 256, *b*) with a rag dipped in gasoline, until it is clean and bright. The distributor arm revolves and makes contact with the segments or brushes to which the wires are attached. In some magnetos it is made of brass, and in others carbon is used. In either case it should be wiped clean and dry. It should never be scraped with a knife.

3. Wipe the segments or brushes, to which the wires are attached, with gasoline until they are clean and dry. These brushes break occasionally, and the springs behind them may lose their tension. Replace the brushes and springs if necessary.

4. Examine the surface of these points. If they are burned or pitted they must be filed down smooth and clean. For this purpose a small, flat file (jeweler's file) should be used. In some magnetos these points may be filed down while in the magneto. In others it is easier to remove them before filing. the filing should be done carefully so that the points will meet each other squarely and make a good contact when together.

5. Turn the armature shaft, by cranking the engine until the breaker points are completely open. Measure the distance between the points with a thickness gauge (Fig. 269). An average distance for this opening is 0.015 in. The proper opening should be known, however, and is usually given in the instruction book furnished by the manufacturer of the tractor. The stationary breaker point is usually a screw which may be turned in or out to make the adjustment. A lock nut is provided with which the adjustment is made secure.

6. Lubricate the bearings of the magneto shafts. In most magnetos there are two oil holes, one at either end of the armature shaft. With a small oil-can, pour gasoline into these bearings. This will cut loose any oil that may have dried in them. Soak them thoroughly with gasoline, then let the magneto stand for some time so that this gasoline may evaporate.

Drop a few drops (3 or 4) of light magneto oil into each bearing. Magnetos should be oiled very sparingly. Too much oil in the magneto will cause trouble. The oil may be dropped into the magneto bearings with the aid of a toothpick or piece of wire.

Job. No. 38

TO CLEAN AND ADJUST THE SPARK PLUGS

Note.—The spark plugs must be kept clean. They get dirty quickly if too much oil is used in the engine or if the fuel mixture is too rich. Both one-piece and two-piece spark plugs are commonly used. The latter are easier to clean but are more easily broken than the former. Spark plugs also vary in the thread used at the base of the plug, which screws into the cylinder. If a plug with the wrong thread is forced into the cylinder, it may cause serious damage.

Operations Necessary to Perform the Job.

1. Remove spark plugs.
2. Wash spark plugs in kerosene.
3. Dry spark plugs and examine all parts carefully.
4. Adjust distance between electrodes.

Description of Operations.

1. Remove the spark plugs from the engine.

2. Put the plugs in a can of clean kerosene to loosen the carbon and burned oil. (If the plugs are of the two-piece type, take them apart before putting them in the kerosene.) Let them soak for some time.

3. Wipe all parts dry. Examine the electrodes and the end of the insulation. If the electrodes are burned away or the insulation badly charred, it will be better to replace the plug with a new one. Charred insulation indicates that the electrodes have been set too far apart. (See next paragraph.)

4. Adjust the electrodes carefully. The distance between them varies in different engines. A setting of 0.025 in. will be satisfactory for most tractor engines. The distance between the electrodes should be measured with a thickness gauge (Fig 269).

Make sure that the insulation is clean and not cracked or loose. A loose or cracked insulation will cause the cylinder to misfire.

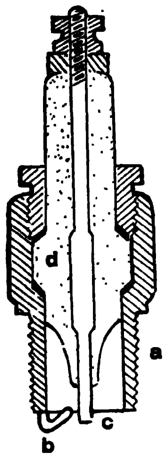


FIG. 257.—Cross section of spark plug.

Note.—A cross section of a spark plug is shown in Fig. 257. The base of the plug (*a*) is made of metal. It is threaded at the bottom, where it is screwed into the cylinder. The central portion (*d*) is made of an insulating material, such as porcelain or mica. The central electrode (*c*) passes through the porcelain or mica and is thus insulated from the metallic base of the plug. The outer electrode (*b*) is directly connected to the base and thus grounds the electric circuit.

Adjustment is made by bending the outer electrode to get the proper spacing between the two electrodes. The spark occurs when the secondary current jumps the gap between the electrodes (*b* and *c*).

LABORATORY STUDY NO. 35

To study, clean, and adjust all parts of the Fordson tractor ignition system.

Equipment Necessary.—Fordson tractor, with all parts of the ignition system in proper places.

Note.—The magneto used on the Fordson is a type distinctly different from that described above.

Procedure.

1. Locate the sixteen magnets of the magneto. They are attached to the flywheel with clamps. These parts are enclosed in the tractor and cannot be seen unless the tractor is taken apart. Figure 258, *B*, shows them clearly. Figure 258, *B*, represents the flywheel with the magnets and clamps.

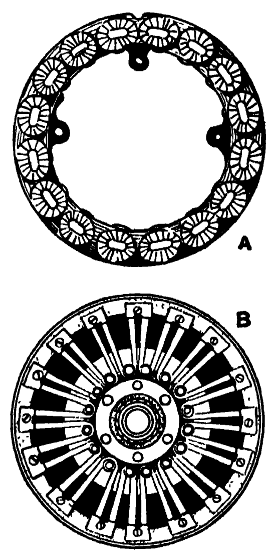


Fig. 258.—Fordson magneto.

2. Locate the magneto coils (Fig. 258, *A*). There are sixteen of these coils, all wound with one continuous flat copper wire. One end of this wire is grounded to the metal of the engine; the other end is connected to the magneto contact terminal (Fig. 259, *g*). In the Fordson magneto the magnets revolve and the armature is stationary. The magnet clamps, when revolving, clear the core of the magneto coils by $\frac{1}{32}$ in.

3. Loosen the three screws which hold the magneto contact terminal (Fig. 259, *g*) in place and remove it. Wipe the contact spring clean and see that it makes a firm contact with the magneto coil.

4. Disconnect the wire leading from the magneto to the coil

box (259, *a*). Wipe off the porcelain insulation on the coil box to which this wire is attached and then replace the wire.

5. Unlatch the top of the coil box (Fig. 259, *b*) and pull all four of the induction coils out of the box.

6. Notice the brass strip in the bottom of the coil box. This strip carries the current from the magneto into all four of the coils. The wire from the magneto, which was removed

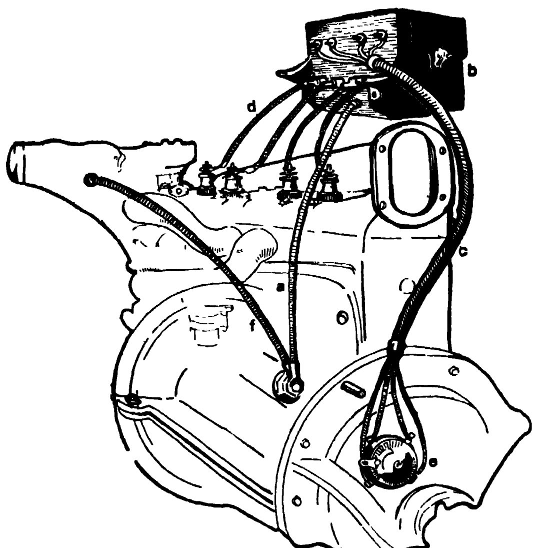


FIG. 259.—Wires used in Fordson ignition system.

and cleaned in instruction No. 4 above, leads to this strip. Wipe the brass strip clean and dry.

7. Examine one of the four coils. It has one contact terminal on the bottom and two on the back. The bottom one carries the primary current of the magneto from the brass strip into the coil box. The upper terminal on the back carries the primary current from the coil to the wire leading to the commutator (Fig. 259, *c*). The lower terminal on the back of the

coil carries the secondary current from the coil to the wire leading to the spark plug (*d*).

Note.—The interior construction of the induction coil is shown in Fig. 263, and its action is explained in instruction No. 13 below. Wipe all the contact terminals clean.

8. Examine the vibrators on top of the coils (Fig. 260). Note the stationary bridge (*a*) across the top of the vibrator. This bridge carries a small point of tungsten metal on its under side. Note the movable armature (*c*) below the bridge. This carries a point of tungsten metal on its upper side. The adjustment and care of these points are important. They should be adjusted so that there is a gap of $\frac{1}{32}$ in. at the point indicated by the arrow (*d*).

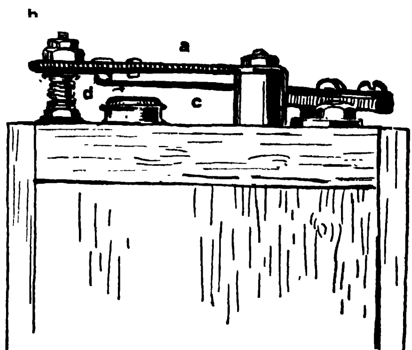


FIG. 260.—Detail of vibrator.

This adjustment is made by the two nuts (*b*). Clean the points with a small, flat file. Hold the armature down and insert the file between the points. In this way both points may be filled at once and may be more easily kept level. File until all pits are removed and the surface of the points is clean and bright.

9. Note the four wires that connect the upper terminals of the coils to the commutator (Fig. 259, *c*). Disconnect these wires from the coil box. Wipe off the porcelain insulators to which they connect, and replace the wires. Be sure to replace them in their original position.

10. Locate the commutator (Fig. 259, *e*). Remove the commutator case. To do this, take the cotter pin out of pullrod connection (Fig. 261, *c*) and loosen the nut that holds the flat spring (261, *A*). Examine the metal segments (*a*). These

should be smooth, not rough or ridged. If the surface of these segments is rough, the commutator roller (*b*) makes a poor contact, and a very weak spark is given at the spark plug. If the insulation between these segments becomes oil-soaked and dirty, it may cause a short circuit between the segments and uneven firing of the engine. Clean the outside of the commutator case. If the commutator segments have become rough, or the insulation oil-soaked, the entire commutator case should be replaced.

11. Note the hole in the top of the commutator case

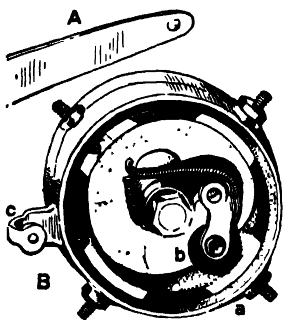


FIG. 261.—Detail of commutator.

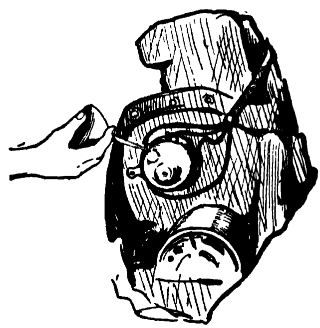


FIG. 262.—Oiling the commutator.

(Fig. 262). This should be oiled at least twice for every ten hours of operation. Frequent oiling prevents rapid wear of the roller and segments. The oil used in the crankcase of the engine may also be used for this purpose.

12. Note the commutator roller (Fig. 261, *b*). This roller revolves and makes contact with each of the four segments. When it is touching a segment, the coil which is attached to that segment will be brought into action and will send a spark to the cylinder to which it is connected. The commutator roller must make a good, firm contact with the segment. The current that flows here is low-tension, that is, there is a low electrical pressure behind it, and it must have a good path to travel

over. The spring which holds the roller against the contact point must be of proper tension. It frequently becomes weak and must be replaced.

13. Study the interior construction of the Fordson induction coil unit (Fig. 263). The current from the magneto is a low-tension, alternating current of about 20 to 25 volts when the motor is running at 1000 R.P.M. This current enters the coil at the primary contact terminal (*k*) and flows around the primary winding. The primary winding (*f*) is composed of 222 turns of coarse, insulated copper wire, which is wrapped around a soft-iron core (*j*). The current generated by the magneto flows through the primary winding and magnetizes the core. This core, when magnetized, pulls down the vibrator armature which separates the vibrator points, and stops the flow of the primary current. When the current is stopped, the core becomes demagnetized, the vibrator points spring back together, the current starts flowing again, and the same process is repeated. This action takes place very

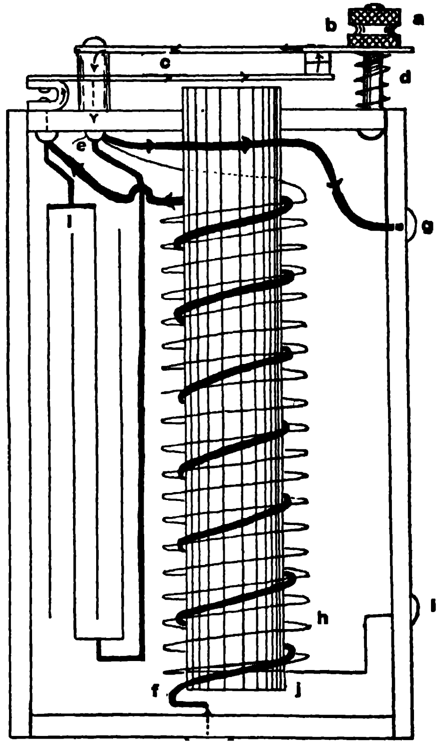


FIG. 263.—Cross section of Fordson induction coil.

rapidly, so rapidly that the vibrator, springing back and forth, gives a steady buzz. Each time the vibrator points are together, the soft-iron core becomes a magnet and has a magnetic field about it. Every time the vibrator points separate, this magnetic field is destroyed and a current of high voltage is induced in the secondary winding (*h*). This quick change in the strength of the magnetic field generates a current of great strength or voltage (8000 to 20,000 volts) in the secondary or high-tension circuit. The secondary winding is composed of 16,400 turns of very fine insulated copper wire, one end of which is connected to the primary at (*e*), and the other brought out to the secondary (high-tension) terminal at (*i*). From here it is carried by a heavily insulated wire to the spark plug. The condenser (*l*) which might be called an electric sponge, is composed of alternate sheets of tin foil and wax paper, rolled up and pressed together under heat. It has the ability to soak up or store electricity for a short interval. By absorbing any excess current which might arc across the points while they are opening, it helps to make the primary current stop flowing the instant the vibrator points open. It also prevents the excessive sparking and pitting of the vibrator points. A large, red spark at the vibrator points causes the points to burn out quickly and indicates a broken-down condenser. Trace the path of both currents through the induction coil. The arrow points indicate the path of the primary current through the coil.

14. Remove one of the spark plugs. Note the distance between the points. This should be $\frac{1}{32}$ in.

At the base of the plug are two electrodes, one of which passes through the center of the porcelain; the other is attached to the metal shell. The current in the secondary circuit, because of its very high voltage, is forced to jump across the space between these electrodes, thus causing a spark which lights the fuel.

15. Adjust all four spark plugs to $\frac{1}{32}$ in. gap. Have them clean and dry. Be particularly careful to remove all burned oil or carbon from the porcelain.

16. Locate all wires used in the ignition system.

There are ten external wires used in the Fordson Ignition System. One of these leads from the magneto contact terminal to the coil box, and then, through a connection, to the brass rail in the bottom of the coil box (Fig. 259, *a*). Four heavily insulated wires or cables run from the lower contact terminals on the back of the coil box to the cylinders (Fig. 259, *d*). These wires run in direct order. Number 1 spark plug, which is nearest to the radiator of the tractor, connects with a wire to No. 1 coil, which is also the one nearest the radiator. Spark plugs and coils are numbered from the front backward, in direct order to No. 4. Number 2 spark plug is connected to No. 2 coil, No. 3 spark plug to No. 3 coil, and No. 4 spark plug to No. 4 coil. Four small wires, all assembled in a conduit (Fig. 259, *c*) lead from the upper contact terminal on the back of the coil to various sections of the commutator. The wire from No. 1 coil is usually colored " olive," and leads to the commutator segment No. 1. This is the segment directly above the pull-rod connection (Fig. 261, *c*) on the commutator case. To aid in tracing them through the conduit, these wires are given four different colors. Number 2 coil, or the black wire, is attached to the commutator segment directly below the pull-rod connection. Number 4 coil, or the green wire, is attached to the next commutator segment, and No. 3 coil, or the red wire to the last segment.

This means that No. 1 cylinder will receive a spark first, then No. 2, then No. 4, and finally No. 3. The firing order is, therefore, 1-2-4-3.

Whenever the commutator roller is in contact with the segment that connects to No. 1 coil, No. 1 spark plug will be receiving a spark. When the roller is in contact with the segment to which No. 2 is attached, No. 2 spark plug will receive the spark, and similarly for No. 3 and No. 4 spark plugs. The last of the ten wires (Fig. 259, *f*) of the Fordson Ignition System leads from the magneto contact to the switch terminal on the dash. When this switch is closed the current from the magneto

is diverted from the coils and grounded. Hence this switch is used to stop the motor and is called the "shorting switch."

17. The spark is retarded by shifting the commutator case in the same direction that the commutator roller revolves. In this position the roller will touch No. 1 segment just as No. 1 piston reaches the top of its stroke. Remove the spark plug from No. 1 cylinder and crank the motor slowly until the commutator roller just touches No. 1 segment. It will now be possible to feel No. 1 piston with a wire inserted through the spark-plug hole. It should be at the very top of its stroke.

18. The spark is advanced by moving the commutator case in the opposite direction from that in which the commutator roller revolves. Crank over the motor again until the roller just touches No. 1 segment. Now note the position of the piston in No. 1 cylinder. It has not yet reached the top of its stroke. The spark is therefore said to be early or advanced.

Caution.—The spark lever should always be retarded when cranking the motor. It should always be advanced when the motor is running, as running the motor with a retarded spark will cause overheating.

QUESTIONS

1. Where are the two ends of the flat copper wire of the magneto coils fastened?

2. Between what two parts does the magneto contact (Fig. 259, *g*) make connection? (Wires *a* and *f*, Fig. 259, are attached to the magneto contact.)

3. How is the current from the magneto distributed to the four coils in proper order?

4. Describe the purpose of the three contact terminals on the Fordson coil unit.

5. What is the function of the primary winding of the coil unit?

6. What is the function of the secondary winding of the coil unit?

7. Would you get a severe shock by touching a commutator segment when the motor is running?

8. Would you get a severe shock by touching a spark plug when the motor is running?

9. If the vibrator points of a coil spark heavily, what is wrong?

10. Draw a diagram or sketch showing how the wires are connected from each of the four coil units to the commutator.

11. Would a satisfactory spark be secured if the vibrator points were spaced too far apart?

12. Would a satisfactory spark be secured if the vibrator points were spaced too close together?

13. Tell briefly the purpose of each of the external wires of the ignition system.

14. Why is it necessary to provide a good passage for the electric current across the vibrator points?

15. Trace the path of the primary current throughout its entire circuit, naming in order every part through which it

16. Trace the path of the secondary current throughout its entire circuit, naming in order every part through which it passes.

17. Explain how you would check up to determine if the ignition is properly timed.

COMMON IGNITION TROUBLES

The ignition troubles described in the following paragraphs are easily located and quickly remedied by an efficient tractor operator. If the ignition system is kept in good condition, and if the adjustments described in this chapter are carefully maintained, ignition troubles will be largely avoided.

1. Spark-plug Electrodes Set too Far Apart.—This causes the engine to misfire, particularly at high speeds or under heavy loads. It also causes the end of the insulation in the plug to become charred. Adjust to proper distance.

2. Spark-plug Electrodes Set too Close Together.—This causes the engine to misfire, particularly under light loads. It also is likely to cause the plug to foul, as a bit of oil may bridge across between the electrodes. Adjust to proper distance.

3. Dirty or Fouled Spark Plugs.—These cause the engine to misfire. There are several reasons why spark plugs foul or get dirty.

(*a*) Insulation of the plug cracked.

(*b*) Too much oil in engine.

(*c*) Fuel mixture too rich.

(*d*) Valves not seating properly.

(*e*) Electricity not reaching the spark plug because of trouble in the magneto or in the wires leading to the spark plug.

Remove the plug and clean it. Locate and remedy the cause of the trouble.

4. Loose Wires.—All the wires of the ignition system must be tightly connected, and all the connections clean and dry. Do not allow oil or moisture to collect on the wires or connections.

5. Magneto Breaker Points Out of Adjustment or Dirty.—This causes the engine to misfire or to stop entirely. It frequently causes firing in the muffler. Examine the points. Clean and adjust them as in Job No. 37.

6. Magneto Distributor Arm Dirty.—This causes the engine to misfire and run unevenly. Clean with a cloth dipped in gasoline, as described in Job No. 37.

7. Insulation of Wires Broken or Oil-soaked.—This causes the engine to misfire. Replace the defective wires, or wrap the places where the insulation is bad with tape.

8. Spark Advanced too Far.—This causes a clicking noise in the cylinders. Usually this is noticeable only under very heavy loads, and does not often occur in tractor engines if the magneto has been properly timed to the motor. Check the timing of the magneto (Job No. 36).

9. Spark Retarded too Far.—This causes loss of power and overheating of the engine. Keep the spark advanced as far

as possible whenever the engine is running. (Always retard spark when cranking the engine.)

10. Magneto not Timed Properly.—It is possible for the coupling between the engine and the magneto to wear to such an extent that the timing will be affected. This causes overheating, irregular action, and loss of power. Check the timing as described in Job No. 36 and replace the coupling between the magneto and the engine.

11. Magneto and Wires Wet.—As a result of this condition, there may be no spark delivered to the plugs. In this case the engine will not start. Dry all parts of the ignition system thoroughly.

12. Too Much Oil in the Magneto.—This causes an irregular and weak spark to be delivered to the plugs. Magnetos should be oiled very carefully. Too much oil is harmful.

13. Breaker-point Cam Worn or Loose.—The breaker-point cam (Fig. 256, *d*) may become worn so that it does not open the points properly. This causes weak ignition and irregular operation of the engine. In some magnetos this cam is pinned or keyed to the armature shaft. Test the cam to make sure it is tightly fitted to the armature shaft.

14. Breaker-point Spring Weak.—The breaker points are opened by the action of a cam, as illustrated in Fig. 256, *d*. They are closed by the action of a small spring built into the breaker-point assembly. If this spring becomes weak, the points will not close properly. Such a condition causes misfiring and firing in the muffler, particularly at high engine speeds. A weak breaker-point spring should be replaced with a new one

15. Worn Armature Bearings.—Worn bearings may cause the armature to strike against the pole shoes (Fig. 252, *b*). This condition will result in weak ignition, and the breaker-point cam will not function properly. Ball bearings are used on the armature shaft (Fig. 255, *e*). They are not adjustable and must be replaced if badly worn.

CHAPTER XIV

REPAIRING

The jobs outlined in this chapter have been selected because they are often necessary. They do not include all tractor repair operations; but if the student masters these he should be able to undertake such other jobs as may be necessary.

Job No. 39

TO ADJUST AND REPAIR THE STEERING GEAR

Equipment Necessary.—Tractor, complete with all parts of the steering gear.

Operations Necessary to Perform the Job.

1. Test steering gear for looseness. Adjust mesh of steering worm and gear to take up wear.
2. Inspect and tighten joints on steering arm, drag link, and steering-knuckle arm.
3. Test spindles and spindle pins for wear.
   Put in new spindle pins and spindle-pin bushings if necessary.
4. Clean and refill grease cups or grease-gun fittings on spindle pins.
5. Adjust length of tie rod so that front wheels " toe in " slightly at the front.

Description of Operations.

1. Turn the steering wheel to the right until it just begins to move the front wheels, then turn in to the left until it begins to move the front wheels in the opposite direction. How much play (looseness) does the steering wheel have? It should not move more than 2 or 3 ins. in either direction without turning the wheels. Take up the end play (up and down movement) in the steering-wheel shaft by turning down the adjusting nut An adjustment is usually provided for bringing the worm and the worm wheel of the steering gear into closer contact when they become worn. This adjustment is made on many types of tractors by means of an eccentric bushing provided on the worm-wheel shaft. If such an adjustment is found, loosen the set screws or bolts holding the bushing and turn it until the lost motion between the worm wheel and gear is removed. It may also be possible to separate the worm and worm wheel and move each one, so that when they are remeshed new and

unworn surfaces will be in contact. This is advisable if the worm and worm wheel are badly worn.

If no such adjustment is provided, a complete replacement may be necessary.

2. Examine the connections on the steering arm, drag link (Fig. 264, *b*), steering-knuckle arms (Fig. 264, *a*), and tie rod (Fig. 264, *e*). These connections are usually provided with a simple adjustment. If the ball and socket type of connection is used, as shown in Fig. 264, *b*, take off the removable half of the ball and file it down sufficiently to make the connection tight.

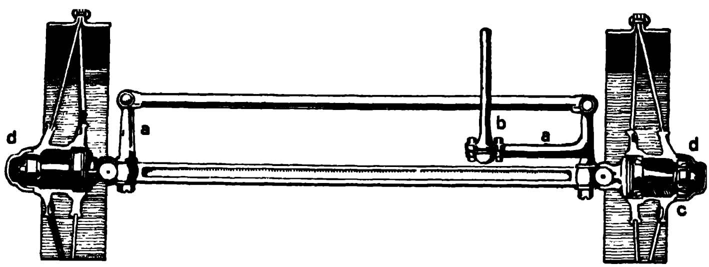


FIG. 264.—Parts of the steering mechanism.

Oil these joints with an oil-can unless fittings or cups are provided for grease.

3. Test the spindles for wear. Figure 265 shows the spindle (*a*) and the spindle pin (*b*) or bolt which attaches the spindle to the front axle. By rocking the spindle up and down, a worn spindle pin will easily be found. Put in a new spindle pin if necessary. On most tractors the spindle pin passes through two brass bushings, one at the top and one at the bottom of the axle. On tractors that have bushings at this point, new bushings will usually take up any looseness.

4. Clean the grease cup on the spindle pins (Fig. 265, *c*). Fill it with fresh grease and turn the cap down until you are sure the grease is being forced out on to the sides of the spindle pin.

5. Adjust the length of the tie rod (Fig. 264, *e*) so that wheels " toe in " slightly at the front.

Job No. 40

TO REPAIR AND ADJUST THE FRONT WHEELS

Equipment Necessary.—Tractor with all parts of front axle and wheels.

Operations Necessary to Perform the Job.

1. Block up front end of tractor.
2. Remove hub cap from one front wheel.
3. Remove cotter pin and nut from outer end of spindle.
4. Remove washer from outer end of spindle.
5. Remove front-wheel and outer-wheel bearing.
6. Remove inner-wheel bearing.
7. Wash bearings and spindle with kerosene.
8. Replace felt washer on inner end of spindle if old one is not in good condition.
9. Remove and clean grease cup or fitting in hub of front wheel.
10. Test bearings carefully, both on spindle and in wheel. Replace them, if necessary.
11. Reassemble all parts in proper order.
12. Tighten nut on end of spindle as required for proper adjustment.
13. Fill hub cap with fresh grease and put it in place.
14. Follow directions given above for other front wheel.
15. Align wheels to "toe in" slightly at front, by adjusting length of tie rod.

Description of Operations.

1. Jack up the front wheels, supporting each side of the tractor securely with blocks.

2. Remove the hub cap from one front wheel (Fig. 265, *d*).

3. Remove cotter pin and large nut found just inside of hub cap.

4. Remove washer found inside of nut at outer end of spindle.

5. Pull off the front wheel. Most tractor front wheels are mounted on two roller bearings. When the front wheel is pulled off, the outer one of these two bearings will be removed with the wheel (Fig. 265, *e*).

6. Remove the inner bearing from the front axle (Fig. 265, *f*).

7. Wash these two bearings thoroughly with kerosene, to remove all sand and grit.

8. Replace the felt washer on the inner end of the axle with a new one. This washer keeps the grease from getting out of

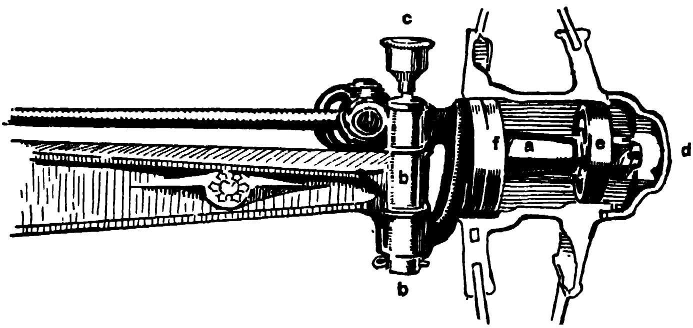


FIG. 265.—Detail of front wheel and front axle.

the axle and also prevents sand and dirt from getting in. These felt washers are not supplied on all tractors.

9. Remove the grease cup from the front wheel. Clean out old grease and wash out all parts. Fill the cup with fresh grease and screw the cap down until it forces the grease out of the bottom of the grease cup. Then replace the grease cup in the wheel.

10. Examine the bearings carefully. Compare them with a new one to see how much they are worn. Test the fit of the bearings on the spindle and in the wheel. They should fit both places. Use new ones, if necessary.

11. Assemble the inner bearing, wheel, outer bearing,

washer, and large nut. Cover the bearings with fresh grease before putting them on the axle.

12. Tighten the large nut as much as possible without preventing the wheel from rolling easily. Rock the wheel sidewise to be sure there is no looseness between the wheel and the spindle. Put the cotter pin through the nut and spread the ends well.

13. Fill the hub cap with fresh grease and replace it on the tractor wheel.

14. Follow the same steps for the other front wheel.

15. Adjust the length of the tie rod (Fig. 264, *e*) so that the wheels "toe in" slightly ($\frac{1}{2}$ to $\frac{3}{4}$ in.) at the front.

Job No. 41

TO CLEAN AND REPAIR THE COOLING SYSTEM

(See Fig. 243)

Equipment Necessary.—Tractor with all parts of cooling system.

Note.—A mixture of 1 part muriatic acid to 7 parts water, kept in the cooling system for thirty-six hours, will loosen up all rust and scale.

Operations Necessary to Perform the Job.

1. Test radiator for leaks.
2. Drain cooling system and remove radiator.
3. Wash out radiator.
4. Wash out water jackets.
5. Solder any leaks in radiator. Remove radiator core from shell or casing, if necessary.
6. Test fan bearing.
7. Inspect and tighten fan blades.
8. Examine fan belt. Replace it, if necessary, and adjust belt to proper tension.

Description of Operations.

1. Fill the system with water and examine the radiator carefully to locate any leaks. Mark the place where the leaks are.

2. Drain water. Remove the radiator from the tractor.

3. Turn the radiator upside-down and wash it out thoroughly. Use a stream of water under pressure if possible.

4. Flush out the water jackets around the cylinders with a stream of running water.

5. Solder any leaks in the radiator. It may be necessary to remove the radiator shell or case to have access to the places to be soldered.

6. Examine the fan bearing. Rock or twist the fan back and forth to determine if the bearing is worn. If so, replace with new bearing. See that this bearing is well lubricated.

7. Examine the fan blades. Tighten the rivets that hold the blades, if necessary.

8. Examine the fan belt. If it is dry and hard or shows signs of being cracked or burned, it should be replaced. When putting these parts together be sure that the fan belt has proper tension. It should be just tight enough to turn the fan without slipping—not too tight.

Job No. 42

TO GRIND THE VALVES AND CLEAN CARBON FROM CYLINDER, CYLINDER HEAD, AND PISTONS

Equipment Necessary.—Tractor engine that has been in service for some time.

Operations Necessary to Perform the Job.

1. Drain cooling system.
2. Remove cylinder head and cylinder-head gasket.
3. Scrape carbon from cylinders, cylinder head and piston head.
4. Remove valves.
5. Mark valves to make sure of replacing them in their original positions.
6. Clean the valve stems.
7. Grind valves.
8. Wash all parts of valves and valve seats with gasoline.
9. Reassemble valves in their original positions.
10. Test tension of valve springs and replace any weak valve springs.
11. Place cylinder-head gasket and cylinder head in position, and tighten all cylinder-head bolts.
12. Adjust valve-stem clearance.

Description of Operations.

1. Drain the water from the cooling system.

2. Remove the cylinder head (Laboratory Study No. 24, page 357).

3. Clean the carbon from the inside of the cylinders, cylinder head, and piston, with carbon scraper or putty knife, as shown in Fig. 266.

4. Remove the valves. To do this it is necessary to compress the valve spring and pull out the small pin or washer which retains the valve spring. This is easily done with a valve lifter, as shown in Fig. 267. A valve lifter can be easily made if there is none in the shop.

5. Mark the valves with a punch mark on the valve head, so that they may be replaced in the same valve seats. Some engines have numbers stamped on the head of the valve for this purpose.

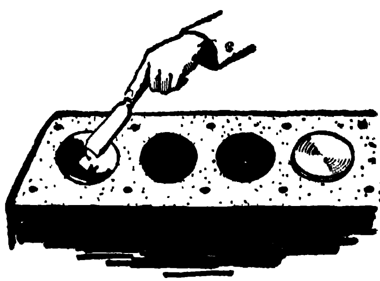


Fig. 266.—Removing carbon from head of piston

6. Clean the valve stems with emery cloth. All carbon must be removed from the valve stem, or the valve will not work freely. Use a fine grade of emery and get the valve stems clean and smooth.

7. Grind the valve (Fig. 268). The object of grinding the valve is to remove all carbon from the face and to make the valve seat tightly.

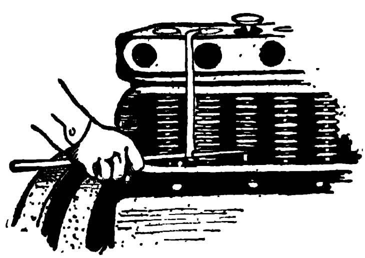


Fig. 267.—Valve lifter.

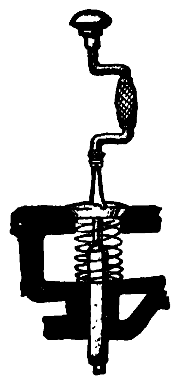


Fig. 268.—Valve grinding.

(*a*) Place a light spring under the head of the valve as as shown in Fig. 268.

(*b*) Spread a light coating of valve-grinding compound under the valve face. (This compound is usually supplied in a can containing two grades, fine and

coarse. Start the grinding with the coarse and finish with the fine grade.)

(*c*) Press the valve down against the seat and oscillate the handle of the tool back and forth. Do *not* turn it around in a complete circle. Raise the valve from the seat frequently and add more compound when necessary.

(*d*) Wash the valve and seat clean with waste and gasoline, and examine the work. Grinding must be continued until all marks and pits are removed and the valve and valve seat are clean and smooth.

8. Wash the valves, valve seats, springs, and the guides through which the valves work, with gasoline.

9. Reassemble the valves in their proper seats with the use of the valve lifter, and put valve retaining washers and pins in place. It is important that these parts be carefully washed before they are put back in the motor. If any of the valve-grinding compound should remain on the valve or valve seat, the valve would not close properly.

10. Test the tension or strength of the valve springs when the valves are in place. This test can be made to the best advantage after the valves have been ground and the valve stems cleaned. All the springs should be equally strong. If any are noticeably weaker than the rest, the weak ones should be replaced with new springs.

11. Reassemble the cylinder-head gasket and cylinder head as described in Laboratory Study No. 24.

12. Adjust the valve-stem clearance as described in Job. No. 43.

Job No. 43

TO ADJUST THE VALVE-STEM CLEARANCE

Equipment Necessary.—Any engine having camshaft, valves, valve tappets, valve springs, and spring retainers in place. If an engine with valves in the cylinder head is used, the push rods and rocker arms are also necessary.

Operations Necessary to Perform the Job.

1. Refer to Figs. 269 and 270. Determine point at which valve-stem clearance is to be adjusted.
2. Crank engine until valve to be adjusted is fully closed. Measure clearance between valve stem and tappet with a thickness gauge.
3. Adjust clearance according to specifications of manufacturer.
4. Secure adjustment with lock nut provided, and check clearance measurement again.

Description of Operations.

1. Study Fig. 269, carefully. When the cam points away from the valve tappet, there is an air space between the valve stem and the adjusting screw. When the engine runs, these parts get hot and expand. If this air space were not provided, these parts, when hot, would touch all the time and the valve would not close. This space varies on different engines. In some it is 0.010 in., in others 0.012 in., etc. The exact spacing should be known. The instruction books provided by the manufacturer give this information. The valve-stem clearance is adjusted between the valve stem and the valve tappet (Fig. 269) or between the rocker arm and the valve stem (Fig. 270), depending upon the type of engine.

2. Crank the engine until the valve you wish to adjust is fully closed. Measure the distance between the valve stem and the tappet adjusting screw with a thickness gauge. (This gauge has a number of leaves of different thickness. Select the proper one for the engine you are working on. See Figs. 269 and 270.)

3. Adjust the space so that you can just move the leaf of

the gauge between the valve stem and the tappet. This adjustment is made by first loosening the lock nut and then screwing the tappet adjusting screw in or out as necessary.

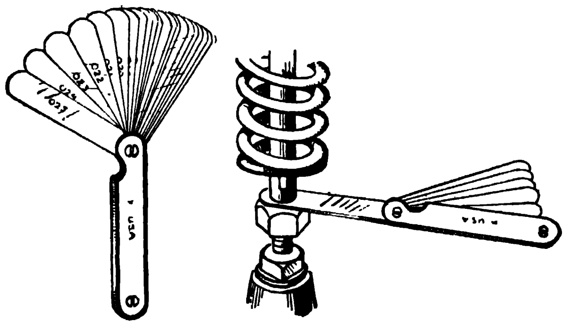


FIG. 269.—Measuring valve stem clearance with thickness gauge.

4. Secure the adjustment when it is right, by tightening down the lock nut (Fig. 269). Measure the space with the gauge again, to make sure that it is right. This adjustment is called the valve-stem clearance. It must be accurate. If there is not enough space here, the valve will open earlier and close later than it should, or it may not seat firmly. If there is too much space, the valve will open later and close earlier than it should. In either case the cylinder will not develop its full power. Insufficient valve stem clearance usually causes the cylinder to misfire at idling speed or when under light loads.

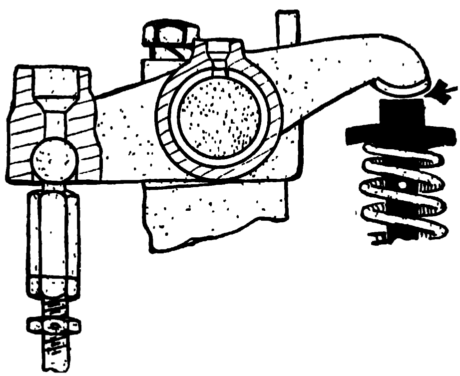


FIG. 270.—Adjustment of valve stem clearance on valve-in-head motor. (Clearance is measured at point indicated by arrow.)

Job No. 44

TO TEST AND ADJUST THE CONNECTING-ROD BEARINGS

Equipment Necessary.—Tractor engine with pistons, connecting rods, and crankshaft. For practice work, the engine need not be in running condition.

Operations Necessary to Perform the Job.

1. Drain oil and remove crankcase.
2. Test each connecting-rod bearing.
3. Remove cotter pins from bearing to be adjusted.
4. Run off castellated nuts from bottom half of bearing.
5. Remove bottom half of bearing.
6. Remove shims, as required.
7. Test bearing.
8. Put in new cotter pins.
9. Adjust any other loose connecting-rod bearings.
10. Put on crankcase gasket and crankcase.

Description of Operations.

1. Drain the oil from the engine and remove the crankcase pan or entire case if necessary (see Laboratory Study No. 23).

2. Test each connecting rod. To do this, crank the engine until any one piston is on bottom center. Push the connecting rod up and down to see if it is loose on the shaft and can be moved vertically.

Note.—A certain amount of horizontal movement or side play is permissible, but there should be no noticeable play up and down. Make this test carefully. It is sometimes difficult to discover a slight amount of wear at this point.

3. Remove the cotter pins from the castellated nuts on the bottom of the connecting-rod bolts (Fig. 271).

4. Run off the castellated nuts.

5. Remove the bottom half of the connecting-rod bearing.

Be careful not to let the shims drop and get mixed up (Fig. 272).

6. Remove one shim from each side of the bearing. (Select those of equal thickness.)

7. Put on the bottom cap again and draw the nuts up tight.

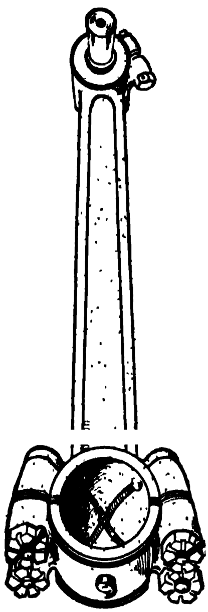


FIG. 271.—Connecting-rod and wrist pin.

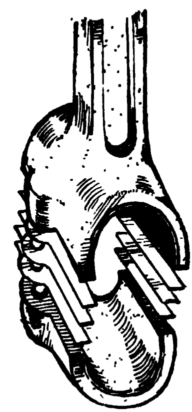


FIG. 272.—Shims used in connecting rod bearings.

While testing the fit of one bearing, loosen the nuts on all the other connecting-rod bearings.

Test the bearing again for looseness. If it is still loose, remove another shim from each side. Continue removing shims until the connecting rod shows no sign of vertical movement when pushed up and down against the crankshaft.

Crank the engine. If the bearing has been made too tight, the engine will turn over very hard. In this case it may be

necessary to add a thin shim to each side. This bearing must be accurately adjusted. It must be neither too loose nor too tight.

8. Put new cotter pins through the castellated nut. Use the largest size possible, and spread the ends carefully. This cotter pin is essential. If the nuts should come off when the engine is running, a serious smash-up would result.

9. Adjust the other loose connecting-rod bearings in the same manner.

10. Replace crankcase. Be sure that the gasket is in good condition (see Laboratory Study No. 23).

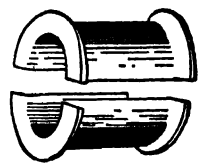


FIG. 273.—Babbitt bushings used in connecting-rod bearings.

11. Tighten all bolts thoroughly. Be sure that all bolts have lock washers. When a connecting-rod bearing is badly worn, it may be necessary to put in new bearing bushings (see Fig. 273). Before these can be put in, they must be scraped to fit the crankshaft. Bearing scraping is taken up in Job No. 44.

Note.—The main bearings of the crankshaft are adjusted in much the same way as the connecting-rod bearings. They are fitted with removable shims also, which should be removed as the bearing wears. It is usually more difficult to test a main bearing, as the whole crankshaft must be moved up and down in the bearing in order to detect the wear. To do this it is advisable to use a bar of iron or a jack so that the shaft may be moved easily. The oil grooves in the bushings of the main bearings and the connecting-rod bearings should always be cleaned out carefully when the adjustment is made.

Job No. 45

TO SCRAPE AND FIT NEW CONNECTING-ROD BUSHINGS

Note.—These bushings are made of soft babbitt metal. The surface looks perfectly true and smooth to the eye, but it is usually not so. There are high spots and uneven places. If a new bushing were placed in the connecting rod in this condition, only the high spots would actually touch the shaft. These would soon wear down. The bearing would quickly become loose, and the engine would knock.

Bearing scraping levels down the high spots and allows all the surface of the bushing to bear on the shaft, thus providing a well-fitted bearing that will give good service.

Equipment Necessary.—Crankshaft; connecting rod; new babbitt bushings; Prussian blue (a blue paste or coloring matter); bearing scrapers.

Operations Necessary to Perform the Job.

1. Give crankshaft a light coat of Prussian blue where the bushing is to be fitted.
2. Assemble connecting rod on crankshaft in inverted position.
3. Rock connecting rod back and forth several times.
4. Remove connecting rod and examine blue marking on bushings.
5. Scrape blue spots lightly.
6. Repeat Operations 1, 2, 3, 4, and 5 until approximately three-quarters of surface of bushings show blue.
7. Assemble bushing permanently in connecting rod and anchor it with pins or screws, if these are provided.
8. Clean oil grooves.
9. File edges of bushings if they project above halves of connecting rod.

Description of Operations.

1. Give the shaft a light coat of Prussian blue, where the bushing is to be fitted. To do this, take a little drop of blue on the end of one finger and rub it completely over the shaft

where the bushing is to be fitted. It is important that a very light coat be given. If the blue is put on too thickly, it will mark all of the bushing and will not indicate its true condition.

2. Place the bushings (Fig. 273) in the connecting rod and assemble the connecting rod on the crankshaft with the upper end down (inverted position), as shown in Fig. 274. Draw the nuts up tight.

3. Rock it back and forth several times.

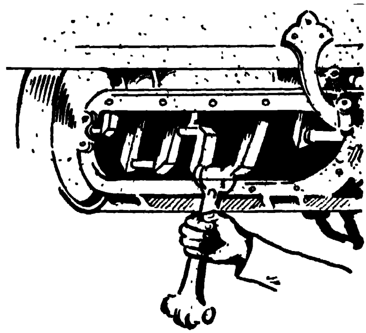


Fig. 274.—Testing fit of new connecting-rod bearing.

4. Take off the connecting rod and examine the bushings. They will probably be marked somewhat like the one shown in Fig. 275, *C*.

5. Scrape down the blue spots very lightly with bearing scrapers, just enough to remove the blue (Fig. 275, *A* and *B*).

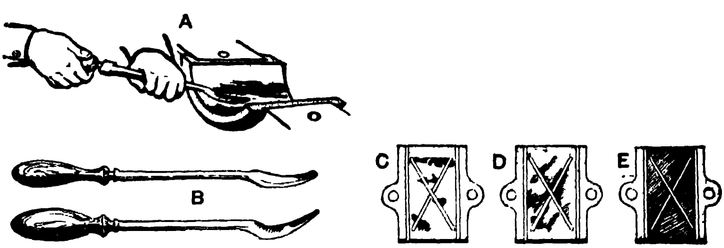


Fig. 275.—Bearing scraping.

6. Blue the shaft again. Put connecting rod on and rock it as before.

Remove the connecting rod and examine the bushings. This time they should show more blue surface, as indicated in Fig. 275, *D*.

Repeat the process until at least three-quarters of the bearing surface is marked by the shaft (Fig. 275, *E*).

7. Assemble the bushings permanently in the connecting rod.

Anchor the bushings, with the rivets or screws provided, to both halves of the connecting rod.

8. Clean out the oil grooves in the bushings.

9. File off the edges of the bushing if they project above the

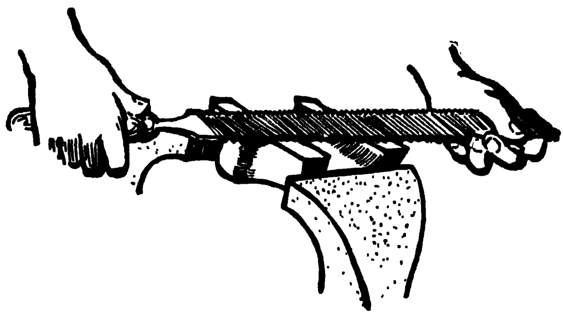


Fig. 276.—Filing down edges of babbitt bushings.

sides of the connecting rod (Fig. 276). The new bearing is now ready to be adjusted to the crankshaft by means of the shims, as described in Job No. 44.

Note.—New bushings for the main bearings must be fitted and scraped in the same manner as connecting rods. Bearing scraping requires careful, accurate work. The student should be given several practice jobs before he is allowed to fit bearing on a motor that is to be used for field service.

Job No. 46

TO REMOVE THE PISTON, CLEAN THE PISTON RING GROOVES, AND FIT NEW PISTON RINGS

Equipment Necessary.—Complete tractor engine.

Note.—New piston rings are required when the old piston rings allow oil to pass them and enter the combustion chamber. This causes the spark plugs to foul quickly. Worn piston rings also cause loss of power and rapid dilution of the oil in the crankcase.

Operations Necessary to Perform the Job.

1. Take off crankcase pan.
2. Take out cotter pins and remove castellated nuts from one connecting rod.
3. Remove lower half of connecting-rod bearing.
4. Remove piston.
5. Remove piston rings.
6. Clean carbon out of ring grooves.
7. Fit new rings to piston.
8. Fit new rings to cylinder.
9. Fit new rings to other pistons in same manner.
10. Turn rings on piston so that ring ends are not in line.
11. Oil each piston and cylinder wall and replace pistons.
12. Adjust connecting-rod bearings and reassemble all parts.

Description of Operations.

1. Take off the lower half of the crankcase or crankcase pan so as to expose the connecting-rod bolts.

2. Take out the cotter pins and remove the castellated nuts from the connecting rod.

3. Pull off the lower half of the connect'ng-rod bearing. Be careful not to let the bearing shims fall and get mixed up. Lay them aside carefully so that they may be replaced on the same side of the bearing from which they were taken.

4. Swing the connecting rod to one side of the crankshaft and pull the piston out as shown in Fig. 277.

Note.—In some engines there is not room enough for the piston to pass down past the crankshaft. In this case it is necessary to remove the cylinder head and take the piston out of the top of the cylinder.

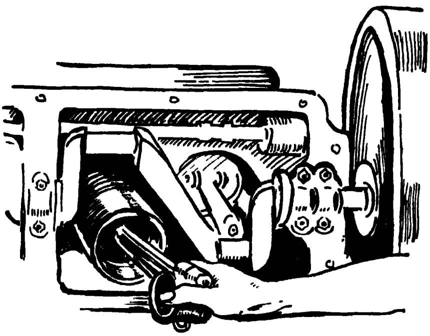


Fig. 277.—Removing piston.

5. Remove the rings from the piston, using three thin strips of metal as shown in Fig. 278.

6. Scrape all the carbon out of the ring grooves.

7. Fit the new ring to the piston. To do this, place the new ring in the groove as shown in Fig. 279, and roll it clear around the piston. If the ring sticks in the groove, place it flat on a sheet of emery paper and rub it down. The ring

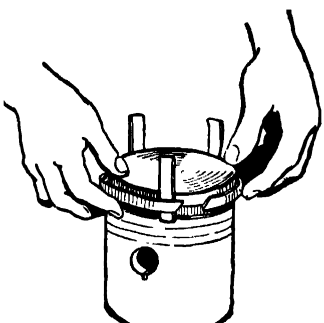


Fig. 278.—Removing rings from piston.

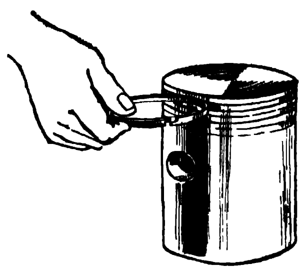


Fig. 279.—Testing ring in piston groove.

must fit well down into the bottom of the groove. It should not be too loose. It should be fitted with not more than 0.002 clearance, that is, so that the 0.002 leaf of the thickness gauge can be pushed in between the ring and the side of the groove.

8. Fit the new ring to the cylinder. This is done as shown in Fig. 280. Place the ring squarely in the cylinder and measure the gap between the ends of the ring with a thickness gauge. This is usually about 0.010 in. for the top ring. If it is less than this, take the ring out of the cylinder and file it through the cut in the ends of the ring with a small, flat file. Be sure to file on the same angle that the ring is cut. Try the ring in the cylinder again. It is necessary to have just the right space between the ends of the ring when it is in the cylinder. If the space is too small the ring, when heated, will expand; the ends will come together and the ring may break or score the cylinder. If the distance is much more than 0.010 in., the ring cannot be used, as this much space would allow the compression and power to escape past the piston.

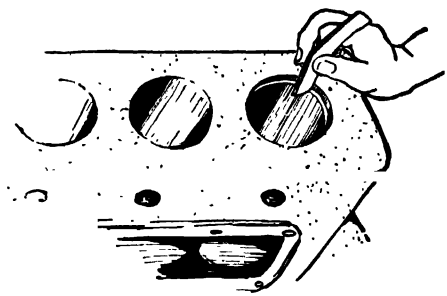


Fig. 280.—Testing ring in cylinder.

The second ring is usually given a smaller clearance than the top one, as it is subject to less heat. The specifications of the manufacturer should be followed on the clearance of all the piston rings. If they are not available, satisfactory results will be obtained by giving the top ring 0.010 clearance, the second 0.008, and the remaining rings 0.006.

9. Fit all the rings in the same manner and assemble them on the piston. In some cases the bottom side of the rings is a trifle larger than the top. This is usually marked, and the

rings should always be assembled with the larger (marked) side down.

10. Turn the rings on the piston so that the gaps between the ends of the rings do not fall in a line. Place the gaps about 120° apart.

11. Rub each piston and cylinder with oil and replace the pistons in the same cylinder from which they were removed.

12. Reassemble and adjust all the connecting-rod bearings. Reassemble all parts.

Job No. 47

TO TEST THE WRIST-PIN BEARING AND TO FIT NEW WRIST-PIN BUSHINGS

Equipment Necessary.—Piston; wrist pin; and bushings.

Operations Necessary to Perform the Job.

1. Test wrist-pin bushings for wear.
2. Remove wrist pin and bushings.
3. Inspect wrist pin for wear.
4. Install new wrist-pin bushings.
5. Install new wrist pin.
6. Test fit of new wrist pin and bushings.

Description of Operations.

1. Refer to Fig. 281, *A* and *B*. There are two types of wrist pins in general use. One, the stationary type (*A*), is

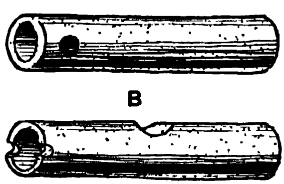
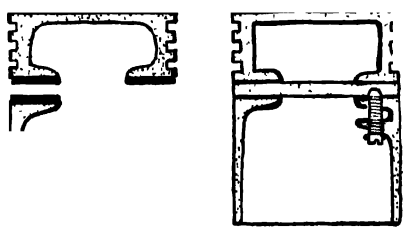


Fig. 281.—Two types of wrist pins.



A B

Fig. 282.—Connection of wrist pin to piston.

fastened by a set screw near its outer edge to the piston (Fig. 282, *B*). The removable bushing in this case is between the connecting rod and the wrist pin. The other, the oscillating type (Fig. 281, *B*), is clamped securely to the connecting rod by a bolt passing through a groove in its center (Fig. 281, *B*). In this case renewable bushings are pressed firmly over each end of the wrist pin into the piston (Fig. 282, *A*).

Test to see if the wrist-pin bushing is worn (Fig. 283). Hold the piston firmly with one hand and force the connecting

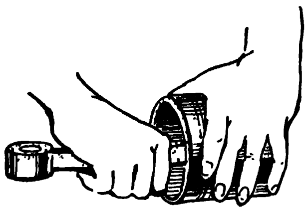


FIG. 283.—Testing wrist pin bearing.

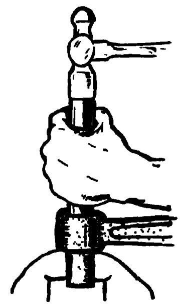


FIG. 284.—Removing wrist pin from connecting rod.

rod back and forth. If there is wear in the wrist-pin bushings they must be replaced. These bushings are not adjustable.

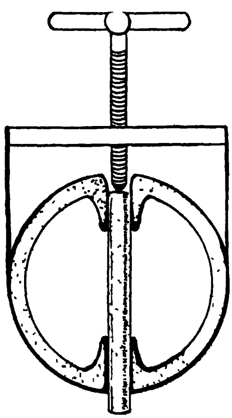


FIG. 285.—Tool for removing wrist pin and bushings.

2. Remove the wrist pin and wrist-pin bushings. Figure 284 shows one method of removing the wrist pin. Figure 285 shows a tool used for removing wrist pins or wrist-pin bushings. Such a tool may easily be made if there is none in the shop.

(*a*) Loosen the set screw that holds the wrist pin to the piston of the clamp bolt that holds it to the connecting rod.

(*b*) Press the wrist pin out of the piston. If the pin is tight, it is advisable to use the wrist-pin remover (Fig. 285).

(*c*) Remove the wrist-pin bushings from the piston or the connecting rod as shown in Fig. 285. The

bushings may be pressed out of the piston by using the piston-pin removeri The bushing is pushed to the inside of the piston.

3. Examine the wrist pin. If it shows any signs of wear, a new one should be used.

4. Press new bushings into the pistons or into the upper end of the connecting rod. The bush ngs must enter straight and fit tight. It should require a firm pressure to force them in. The bushings should be pressed into the piston until they clear the outside of it by $\frac{1}{32}$ in. (Fig. 282, *A*).

5. Fit the new wrist pins into the bushings. Select a wrist pin that fits the bushing tightly. If the pin is too tight and will not enter the bushing, the bushing must be enlarged slightly. To do this, a reamer is used. If the bushing needs only a slight enlargement, it can be ground out with emery paper. Wipe the bushings an l pin clean, after they are properly fitted. Rub oil in the bushings and on the wrist pin. Assemble the parts and tighten the set screw or clamp bolt.

6. Test for accuracy of fit, as follows:

(*a*) Place piston in inverted position on bench and hold connecting rod upright.

(*b*) Jar the bench or tap the connecting rod slightly. It thould fall gradually of its own weight.

CHAPTER XV

LOCATING TRACTOR TROUBLES

A good tractor operator can recognize immediately any of the following conditions:

1. Any irregular running of the engine.
2. Signs of overheating.
3. Unusual noises or knocks.
4. Loss of power.

When any of these develop he stops the engine and removes the trouble. If the engine does not start quickly, he does not continue to crank it but finds the cause of the trouble and remedies it. When the engine begins to knock, he should be able to determine what is causing the knock without taking the engine apart. If he can do this, then, when he is ready to repair or replace the parts causing the trouble, he does no unnecessary work.

The student should practice operating the tractors in the laboratory until he " learns their language." His ear must be trained to know the sound of a perfectly running motor, and to detect any sound of skipping or uneven running. He must learn to watch the exhaust for any sign of black smoke, which will tell him that the fuel mixture is too rich, or any sign of white smoke, which will tell him there is too much oil in the engine crankcase. He will learn to recognize the odor of burning oil, which will tell him that the engine is overheated.

The tractor operator must be keenly alert at all times, or he will never be efficient. Much practice is necessary to become a skillful tractor operator.

The following problems take up some of the simpler tractor

troubles. They will bring out some of the points mentioned above and give the student some operating experience. The students should spend as much time as possible on this work, and the instructor may add other problems to the list. An interesting method to follow is to have the students fix up trouble for each other. One student will put the tractor out of adjustment so that it will not start, and another student must find the trouble, remedy it, and start the engine. Or an engine may be adjusted by one student so that one cylinder will not fire. Another student is required to remove the cause of the trouble and start the engine. This work is called "Trouble Shooting."

LABORATORY STUDY NO. 36

To start the engine and " short " one cylinder.

Equipment Necessary.—Any four-cylinder tractor engine in running condition.

Procedure.

1. Fill the fuel tank with gasoline. (It is advisable to use gasoline for all laboratory practice. Frequent starting and stopping the engine makes the use of kerosene very inconvenient.) Open the shut-off cocks underneath the fuel tanks.
2. Fill the crankcase with oil up to the proper level.
3. Fill all grease cups and turn down the grease-cup caps.
4. Oil all parts that require oiling, with hand oil-can.
5. Fill the air strainer with water to level mark (if water type is used).
6. Trip the impulse starter (if any is used on the engine).
7. Retard the spark lever. Be sure the ignition shorting switch is open.
8. Open the throttle lever half way.
9. Crank the engine. Pull choke lever on carburetor, if necessary.
10. Advance the spark lever fully as soon as the engine starts (never allow the engine to run long with the spark retarded).
11. Let the motor run slowly and easily until warm.
12. Adjust the carburetor needle valve, as described in Laboratory Study No. 33.
13. Take a wooden-handled screw driver and place the end of the blade against the metal of the motor. Touch the middle portion of the blade against the top of the spark plug. This is called " shorting," or " short-circuiting," the cylinder, and it stops the cylinder from firing.
14. Listen carefully to the sound of the engine when this cylinder is " shorted." Try this several times until you know how a four-cylinder engine sounds when one of the cylinders is not firing.

LABORATORY STUDY NO. 37

To locate a missing cylinder

Equipment Necessary.—A four-cylinder tractor engine in running condition. A spark plug in one cylinder should have the electrodes set by the instructor so that there is no gap between them. This will cause the cylinder to " miss."

Procedure.

1. Start the engine, as described in Laboratory Study No. 36.
2. Short the cylinders, one after the other.
3. Notice the effect of shorting each cylinder.

    (*a*) Does the motor slow up each time a cylinder is shorted? Which cylinder, when shorted, does not slow up the engine?

4. Stop the engine. Remove the spark plug from the cylinder which, when shorted, did not slow up the engine.
5. Adjust the spark-plug electrodes carefully, and replace the plug in the cylinder.
6. Start the engine and short this cylinder again. Does it slow up the engine now?

Note.—This is the best method of locating a missing cylinder. Short one cylinder after the other, with a screw driver. If the cylinder is working properly, when it is shorted the engine will slow up. If a cylinder is " missing," shorting it will make no change in the sound of the motor.

LABORATORY STUDY NO. 38

To determine the effect of the valve-stem clearance being out of adjustment.

Equipment Necessary.—Tractor engine in running condition. Valve-stem clearance on one valve is adjusted by the instructor so that valve will not close.

Procedure.

1. Start the engine, as described in Laboratory Study No. 36.
2. Locate the cylinder that is not firing.
3. Stop the engine.
4. Examine the valve-stem clearance on both the valves in this cylinder.
5. Adjust the valve-stem clearance properly as explained in Job No. 43.
6. Answer the following questions.

    (*a*) How would a weak valve spring affect the running of the engine?

    (*b*) How would a sticking valve affect the running of the engine?

    (*c*) What effect do dirty valves have on compression?

    (*d*) Why is valve grinding necessary?

    (*e*) How can you tell, without taking the engine apart, if the valves need grinding.

LABORATORY STUDY NO. 39

To locate a loose connecting rod and bearing.

Equipment Necessary.—Tractor engine with one loose connecting rod. An old engine should be used for this problem. It must be run just long enough for the student to determine which connecting rod is loose.

Procedure.

1. Start the engine.
2. Run the engine fast, and then slow it down until the knock, caused by the loose bearing, is as loud as you can possibly make it.
3. Short the cylinders, one after the other. (The knock will decrease when you short the cylinder that has the loose connecting rod in it.)
4. Try this several times until you are sure that you have found the right one.

Note.—A loose connecting-rod bearing knocks more when the load on the engine is light than when it is heavy. A heavy pull usually causes a connecting-rod knock to decrease.

LABORATORY STUDY NO. 40

To wire the magneto to the motor.

Note.—This problem is included in Job No. 36, but it may be repeated with good results.

Equipment Necessary.—Tractor engine in running condition. All spark-plug wires removed. Magneto is not removed and is in proper time with the engine.

Procedure.

1. Determine the firing order (see Laboratory Study No. 34).
2. Crank the engine until No. 1 piston is on top center at the end of the compression stroke.
3. Remove the distributor cover from the magneto.
4. See which segment the distributor arm is pointing to.
5. Connect a wire from this segment to No. 1 spark plug.
6. Connect wires from the other segments to the cylinders, according to the firing order of the engine.
7. Start the engine, to determine if your wiring is correct.

The following list may be used as a basis of problems in locating troubles. These are real troubles that actually occur in field work, and yet they can easily be made to occur in the laboratory. Such work gives the student an excellent opportunity for practice in locating troubles. His success as an operator depends largely upon his ability in this sort of work. He should be given as much experience as possible in trouble shooting. Any of the following troubles may be arranged by one student for another. If the student trying to locate the trouble has no idea where it will be, when he begins work, any one of this list will give him a real test.

1. One or more spark plugs cracked.
2. Vent hole in fuel tank plugged up.
3. Wires from magneto to spark plugs in wrong position.
4. Air leaks between carburetor and cylinders.

5. Fuel line stopped up.
6. Float in carburetor stuck.
7. Breaker points in magneto out of adjustment.
8. Broken spark-plug wires.
9. Poor insulation on spark-plug wires.
10. Petcocks in cylinders open.
11. Needle valve turned down too far.
12. Needle valve open too far.
13. Air intake closed or obstructed.
14. Throttle valve disconnected from lever on steering wheel.
15. Exhaust pipe obstructed.
16. Valve-stem clearance out of adjustment.
17. Secondary air valve in carburetor stuck.

To locate engine troubles quickly, it should be remembered that before an engine will run properly these three basic requirements must be met:

1. Properly vaporized fuel.
2. Good compression.
3. Strong spark.

ENGINE TROUBLE CHART

The following chart of engine troubles and their causes will be helpful in trouble shooting:

I. Engine will not start.

1. Fuel tanks empty.
2. Fuel pipes obstructed.
3. Water in fuel.
4. Carburetor out of adjustment.
5. Cylinder has too much fuel. (Said to be "flooded.")
6. Poor compression. (See Laboratory Study No. 27.)
7. Engine too cold. (Fuel will not vaporize.) Pour warm water into cooling system.

8. Carburetor frozen.
9. Fouled or broken spark plug.
10. Weak spark furnished by the magneto.
11. Wires poorly insulated.
12. Magneto breaker points dirty or out of adjustment.
13. Spark-plug electrodes out of adjustment.
14. Distributor arm wet or dirty.

II. Engine fires irregularly.

1. Carburetor out of adjustment.
2. Spark-plug electrodes out of adjustment or loose.
3. Loose, broken or oil-soaked wire.
4. Poor compression.
5. Sticking valves or weak valve springs.
6. Valve-stem clearance out of adjustment.
7. Water in gasoline.
8. Fuel pipes partially stopped up.
9. Too much oil in engine crankcase.
10. Weak spark from magneto.
11. Air leaks between carburetor and cylinders.
12. Breaker points in magneto out of adjustment.

III. Engine misses regularly in one cylinder.

1. Fouled or broken spark plug.
2. Sticking valve or weak valve spring.
3. Valve-stem clearance out of adjustment.
4. Loose or broken wire.
5. Spark-plug electrodes out of adjustment.
6. Distributor segment worn or broken.
7. Poor insulation in ignition wire.
8. Burned or dirty valve.

IV. Engine Stops.

1. Fuel tank empty.
2. Fuel line stopped up.
3. Water in fuel.

4. Vent hole in fuel tanks plugged up.
5. Ignition switch in wrong position.

V. Engine overheated.

1. Water too low in radiator.
2. Fan belt slipping or broken.
3. Not enough oil in engine crankcase.
4. Oil pump not working.
5. Too rich a mixture from carburetor.
6. Spark retarded too much.
7. Carbon deposits in cylinders.

VI. Engine knocks.

1. Carbon deposits in cylinders.
2. Spark advanced too far.
3. Engine overheated.
4. Loose connecting-rod bearings.
5. Loose crankshaft bearings.
6. Worn wrist pin.
7. Worn piston.
8. Worn piston rings.
9. Valve-stem clearance too great.
10. Loose flywheel.
11. Worn timing gears.
12. End play in camshaft or crankshaft.

VII. Lack of power.

1. Poor compression.
2. Too lean a mixture.
3. Too rich a mixture.
4. Weak spark.
5. Engine overheated.
6. Spark retarded too far.
7. Clutch slipping.
8. Dragging brakes.

9. Wheel bearings dry.
10. Dirty spark plugs.
11. Dirty valves.
12. Weak valve springs.

VIII. Backfiring through carburetor.

1. Lean mixture.
2. Intake valves sticking open.
3. Dirty intake valve.
4. Wires connected wrong between magneto and spark plug.

IX. Spark plugs foul quickly.

1. No spark delivered to the plug from the magneto.
2. Exhaust valve not closing properly. (Weak spring or sticking valve.)
3. Cracked insulation in spark plug.
4. Poorly fitted or worn piston rings. (This allows oil to work past the piston and foul the plug.)
5. Spark-plug electrodes set too close.

INDEX

M

P